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Technical Report PART I

Geographic Information System for Coastal Area Management and Planning Project

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Technical Report

on the

Geographic Information Systems

Application for Coastal Area

Management and Planning,

Lingayen Gulf Area, Philippines

Part I

CONTENTS

Geographic Information Systems
Applications for Coastal Area Management and Planning
in the Lingayen Gulf Area, Philippines

Introduction

The provinces of Pangasinan and La Union border the 2,100 km^2 Lingayen Gulf in northwestern Luzon, Philippines. The area was the pilot site of the Association of Southeast Asian Nation/US Coastal Resource Management Program for its first regional attempt to promote integrated coastal area management (CAM). The output of the CRMP was a CAM plan aimed at the sustainable development of coastal resources in the Lingayen Gulf area. Significant multiple resource use conflicts pervade in the gulf area which the plan is trying to mitigate.

The completion of the CAM plan and its possible implementation by the National Economic and Development Authority Region I Office (NRO) will require substantial revision to respond to changes in the management area. This is particularly important in light of the current development thrust of the Philippine government to industrialize some areas in Region I and has not been adequately considered in the CAM plan. As such, information management, especially spatial data is needed in order to ensure timely formulation of management options for decision making and policy considerations relative to the development and management programs for the Lingayen Gulf area.

Geographic information systems (GIS) technology has been chosen as the most appropriate tool for spatial data management but this requires pilot testing to determine its suitability and relevance under local institutional setting. Thus. the Geographic Information Systems for CAM and Planning Project (GISCAMP) was implemented with the Lingayen Gulf area as the pilot site to address spatial data management as a complementary mechanism for efficient and timely utilization of information for decision making. The GISCAMP was a 2-year project (September 1991 - February 1994) funded by IDRC with ICLARM as the executing agency.

Rationale and Objectives

One of the recommended strategies of the CAM plan for the Lingayen Gulf is the development of a zonation scheme for both land use and water space utilization. On a broader context, the zonation scheme should consider the downstream impact of hinterland activities so that appropriate management options and policy actions can be formulated to deal with linked habitats such as

forests. Indeed, the CAM plan has addressed such issue with a proposal to rehabilitate the Upper Agno River System watershed (NEDA Region I 1992). The Agno River Basin largely drains into the Lingayen Gulf. Studies on the basin however, have been largely focused on water resource assessment for development purpose with very minimal consideration on the ecological aspect, particularly on the management and conservation of forests. In order to determine what actions to undertake with respect to the rehabilitation of the watershed, it is necessary to quantify the downstream impact of watershed activities such as land use changes in the basin and sediment yield. Thus, critical areas can be determined for rehabilitation activities.

The zonation scheme proposed in the CAM plan is essentially based on ecological and resource management considerations but more focus on the coastal waters component such aquaculture, mangrove rehabilitation, fisheries and marine critical habitats. The terrestrial component such as agriculture, forest land, industrial areas and tourism sites is not well defined. Impacts of development activities, both short- and long-term, for tourism, agriculture, industrialization and urban expansion remain to be assessed and incorporated into the zonation scheme.

The original objectives of the GISCAMP essentially emphasized on all aspects related to zonation but without considering a comprehensive zonation scheme and the impact of development pressures. In light of the recommendations of the CAM plan and recent development programs for the Lingayen Gulf area, the original objectives with respect to the application of GIS for CAM are modified to include a comprehensive zonation in the context of a 6-year development program.

Objectives

1. To evaluate coastal land use changes and marine space utilization with respect to fishing, commercial fry collection, marine parks, mangrove reforestation, aquaculture development, tourism, human settlements and artificial reef sites and their impacts using GIS.

2. To determine the sphere of influence of upland watershed activities in terms of sediment and pollutant influx into coastal areas and their impacts thereof using GIS.

3. To differentiate between natural and anthropogenic changes in the coastal zone, where possible, to pinpoint areas of intense human activities so that appropriate management guidelines can be instituted and to delineate areas for conservation.

4. To develop a zonation scheme for the Lingayen Gulf areas that is consistent with the principles of sustainable development.

5. To establish a databank on spatial and attribute information relevant to CAM and planning at the pilot site.

Methodology

To meet the above objectives, the terrestrial and water components are divided into sectors represented as activities. There are 9 activities with Activity 9 as the integration of Activities 1 to 8 and the development programs for the Lingayen Gulf. The 9 activities are:

Activity 1 *Impact of upland watershed and lowland land use activities on the coastal zone.*

Activity 2 *Impact of human settlement development and expansion on the coastal area.*

Activity 3 *Delineation of fishing zones in Lingayen Gulf.*

Activity 4 *Delineation of fry grounds in Lingayen Gulf.*

Activity 5 *Identification and assessment of marine park and artificial reef zones.*

Activity 6 *Identification and assessment of coastal tourism areas.*

Activity 7 *Identification and assessment of mangrove reforestation areas.*

Activity 8 *Identification and assessment of areas for aquaculture development.*

Activity 9 *Zonation scheme for the coastal zone of Lingayen Gulf.*

Specific GIS procedures are designed for each activity using a GIS software called Spatial Analysis System (SPANS) developed by INTERA TYDAC Technologies of Canada (Version 5.22) for PC microcomputer. Spreadsheets, text editors and database management system (DBMS) are used for processing and analysis of attribute information prior to importation into the GIS. Remotely sensed data (March 1990 Landsat Thematic Mapper) were used to update topographic and thematic maps. Rectification was done by the National Mapping and Resource Information Authority (NAMRIA) using microBrian, an application based image processing system developed by CSIRO and MPA International Pty Ltd of Australia. Ground truthing using Global Positioning System was conducted by the project staff and some information on coral reef

cover was provided by the Marine Science Institute of the University of the Philippines. Photo interpretation of aerial photographs was also conducted by NAMRIA.

To facilitate GIS analysis, each activity follows a standard procedure:

1. Specific objective - defines an objective where GIS can be applied.

2. Information and data needs - define what data are needed in doing the GIS analysis and in what format the data should be collected and processed

3. Flow of processing tasks - define the transformation of data for GIS analysis and the GIS functions to execute in order to meet the objective.

Information and data needs are of two types - map and attribute data. Maps include topographic maps, nautical charts and thematic maps (e.g., soils, slopes, physiography) as well as remote sensed data. Maps including the aerial photographs are digitized using the digitizing package of SPANS called TYDIG (Version 4.3) while remotely sensed data are in digital format imported into SPANS as raster (grid) files. Digitizing was done using a 24" x 36" CALCOMP drawing board II model 33360 with 16 button cursor. Attribute data like population data, number of fishing boats and rainfall data, etc. are encoded in spreadsheets and DBMS following SPANS format and imported as table files. Many of the attribute data collected have to undergo preprocessing to ensure data consistency, detect and correct errors, aggregation and resampling. The latter are for large datasets. Most of the attribute data are point data. Point data are processed in SPANS either as surface maps, point maps or maps with some zone of influence/interest using the buffer function. These various map layers are then overlaid according to specific objectives according to the procedure enumerated above.

An Assessment of the Land Resources in the Provinces of Benguet, La Union, Pangasinan and Tarlac, particularly the Agno River Basin

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Abstract

Land resources in the provinces of Benguet, La Union, Pangasinan and Tarlac were assessed using geographic information systems including the Agno River Basin. Assessment dealt with existing land use patterns, land use change relative to the 1981 forest resource inventory, soil loss and nonpollution source areas. Implications of the findings with respect to the development of the study area, especially for Lingayen Gulf as well as the limitations of this study are discussed. Some recommendations are made to improve the results of the present study and to cushion any economic development earmarked for the four provinces.

Introduction

The Agno River Basin is situated in nine Provinces within four administrative regions (Region I, II, III and the Cordillera Autonomous Region). Its headwaters are located in the boundary of Benguet and Ifugao provinces with a total area of 7,640 km^2 that includes the allied basins in the south part of La Union and Benguet. The allied basins are the Bued and Pantal Rivers (NWRC 1983, JICA/DPWH 1991).

The Agno River drains into the Lingayen Gulf and is a major contributor of sediment load along the gulf including mine tailings. In addition, it periodically causes flooding in the Pangasinan plain, especially during the rainy seasons. Two hydroelectric dams are located in the basin - Ambuklao and Binga

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in Benguet while several irrigation systems are built, mostly in the Pangasinan plain. Hence, development of the water resources of the basin and flood control are important programs of the government.

Major economic activities in the basin are agriculture and mining. Although water resources development is a priority program, very minimal consideration has been given to forest management as an important strategy for water resources conservation and soil erosion, especially in the upper watershed. Siltation of the dams occurred as a result of deforestation along the tributaries while sedimentation occurred throughout the length of the river system due to soil erosion and mine tailing discharge with varying downstream impacts. Major issues affecting the basin are denudation of forests, discharge of mine tailings, erosion and flooding (Briones 1988, NWRC 1983, JICA/DPWH 1991). This paper assesses land use changes and sediment loading in the provinces of Benguet, La Union, Pangasinan and Tarlac as well as the Agno River Basin and their impacts on land development in the coastal areas of Lingayen Gulf.

Methodology

The study area covered four provinces--Benguet, La Union, Pangasinan and Tarlac. The Agno River Basin is a subset of the study area. The basin boundary was delineated by the National Water Resources Council from 1:250,000 topographic maps but the eastern and southern boundaries followed that of the provincial boundaries of Benguet and Tarlac. The study consisted of three parts using geographic information systems (GIS): (a) documentation of land use/cover changes, (b) assessment of soil erosion, and (c) assessment of critical nonpoint pollution sources. The GIS software used is called spatial analysis system (SPANS) developed by INTERA TYDAC of Canada.

For the documentation of land use/cover changes, the 1990 land use/cover, 1981 forest cover, slope, municipal boundaries, sub-basin and basin boundaries including river systems were digitized from various thematic and topographic maps with scales ranging from 1:50,000 to 1:250,000. The land use map was prepared by the Bureau of Soil and Water Management (BSWM) of the Department of Agriculture (DA) while the forest resource condition map was produced by the Forestry Management Bureau of the Department of the Environment and Natural Resources (FMB-DENR). The forest resource condition map was based on the forest inventory of Regions I and III in 1981 using both aerial photographs and field survey under the second National Forest Resources Inventory (BFD 1987a and b). Details of the land use maps (e.g., description of land use/cover, soil types, etc.) can be found in the land resources evaluation project reports for the four provinces (BSWM 1985a, b, c and d). Elevation map was constructed by surface interpolation of digitized spot heights using the triangulated irregular network (TIN) technique (Weibel and Heller

1991). A slope-elevation factor map was generated by overlaying the slope and elevation maps.

Analysis of land use/cover changes were made by two maps overlay process and selectively determined areas of change per specific category (i.e., land use/cover category). The resultant maps were subjected to area analysis including cross tabulation with municipalities and sub-basins of the Agno River Basin, slope and elevation factors. Area analysis was also conducted with the 1990 land use and 1981 forest resource condition maps.

Two models were used in this study. The first model was the determination of sediment loading using the Universal Soil Loss Equation (USLE) (McElroy et al. 1976). The second model was to determine critical areas for nonpoint pollution sources within proximity to water sources (Sivertun et al. 1988). Maps used were soil texture, land use and slope. Attribute data were rainfall, soil erodibility indices, cropping and management factors, drainage density and sediment delivery ratios. Rainfall erosivity map was generated from rainfall data using TIN. Appropriate corrections including computation for missing data were made on the rainfall records to ensure data consistency for the 27 rainfall stations located within and outside of the study areas (Linsley et al. 1988).

The USLE is an empirical, deterministic and lumped model using regression analysis for predicting sheet and rill erosion (McElroy et al. 1976). The sediment loading function is:

$$Y(S)_E = \sum_{i=1}^{n} [A_i(R \bullet K \bullet L \bullet S \bullet C \bullet P \bullet S_d)_1] \tag{1}$$

where:

$Y(S)_E$	=	sediment loading from surface erosion in t/yr;
n	=	number of subareas in the study area;
A_i	=	area extent of subarea i, km^2;
R	=	rainfall erosivity factor;
K	=	soil erodibility factor, t/ha per R unit;
L	=	slope-length factor, dimensionless ratio;
S	=	slope-steepness factor, dimensionless ratio;
C	=	vegetation cover factor (land use), dimensionless ratio;
P	=	erosion control practice factor, dimensionless ratio;
S_d	=	sediment delivery ratio, dimensionless ratio.

The derivation and/or values of the various parameters were computed/taken from various sources: rainfall erosivity and soil erodibility factors (Mitchell and Bubenzer 1980, Landon 1984); slope length-steepness factor (David and Collado n.d.); vegetation cover and erosion control practice factors (David 1987, David and Collado n.d.); sediment delivery ratio (McElroy et al. 1976).

For the nonpoint pollution critical areas, the model determines areas with significantly higher contribution to pollution loading into receiving water than other areas (Sivertun et al. 1988, Reinelt et al. 1989). Nonpoint pollutants are suspended solids, nitrogen, phosphorus and agricultural runoffs. The model uses some parameters from the USLE and has the following form:

$$P = [(K*S*W)/4]*L \tag{2}$$

where

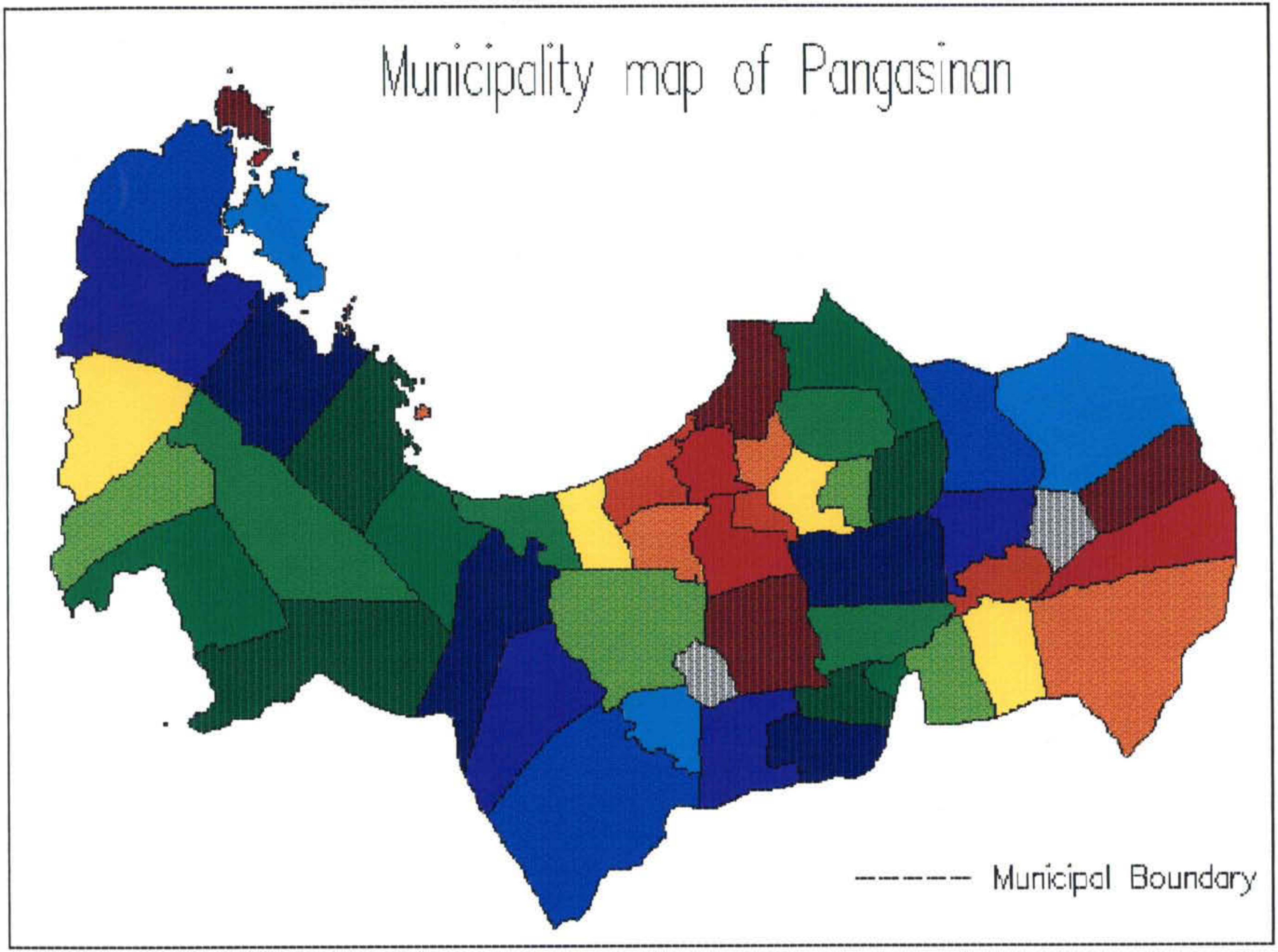
P = product map;
K = soil erodibility index;
S = slope;
W = water course representing distance from river bank; and
L = cropping factor.

Spatial modelling in table form was made for Eqs. (1) and (2). In the latter, the histogram generated was used to reclassify the model result into discrete intervals. Area analysis including area cross tabulation were conducted on the results of the two models with elevation, slope, land use, sub-basin and municipality.

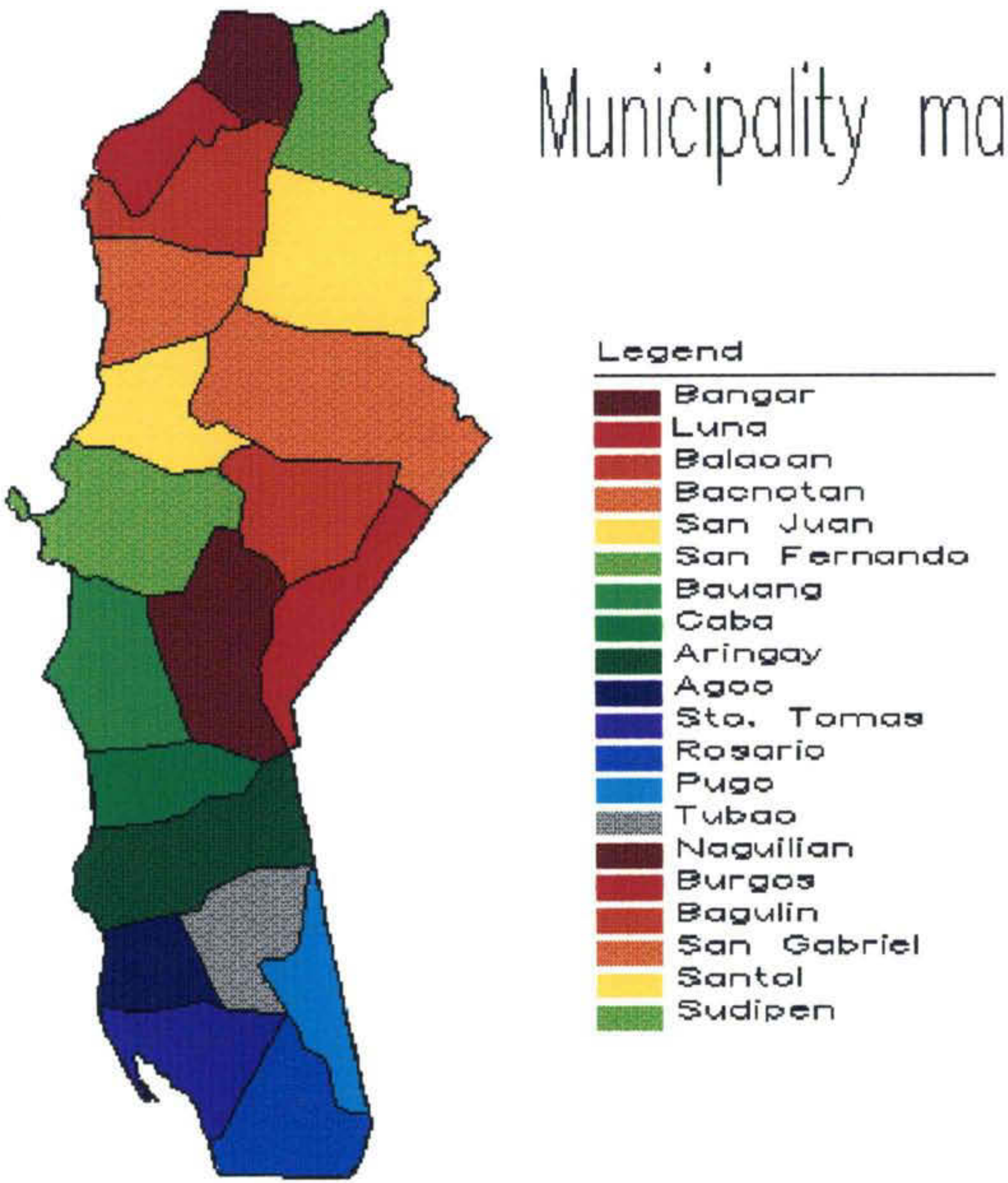
Results and Discussion

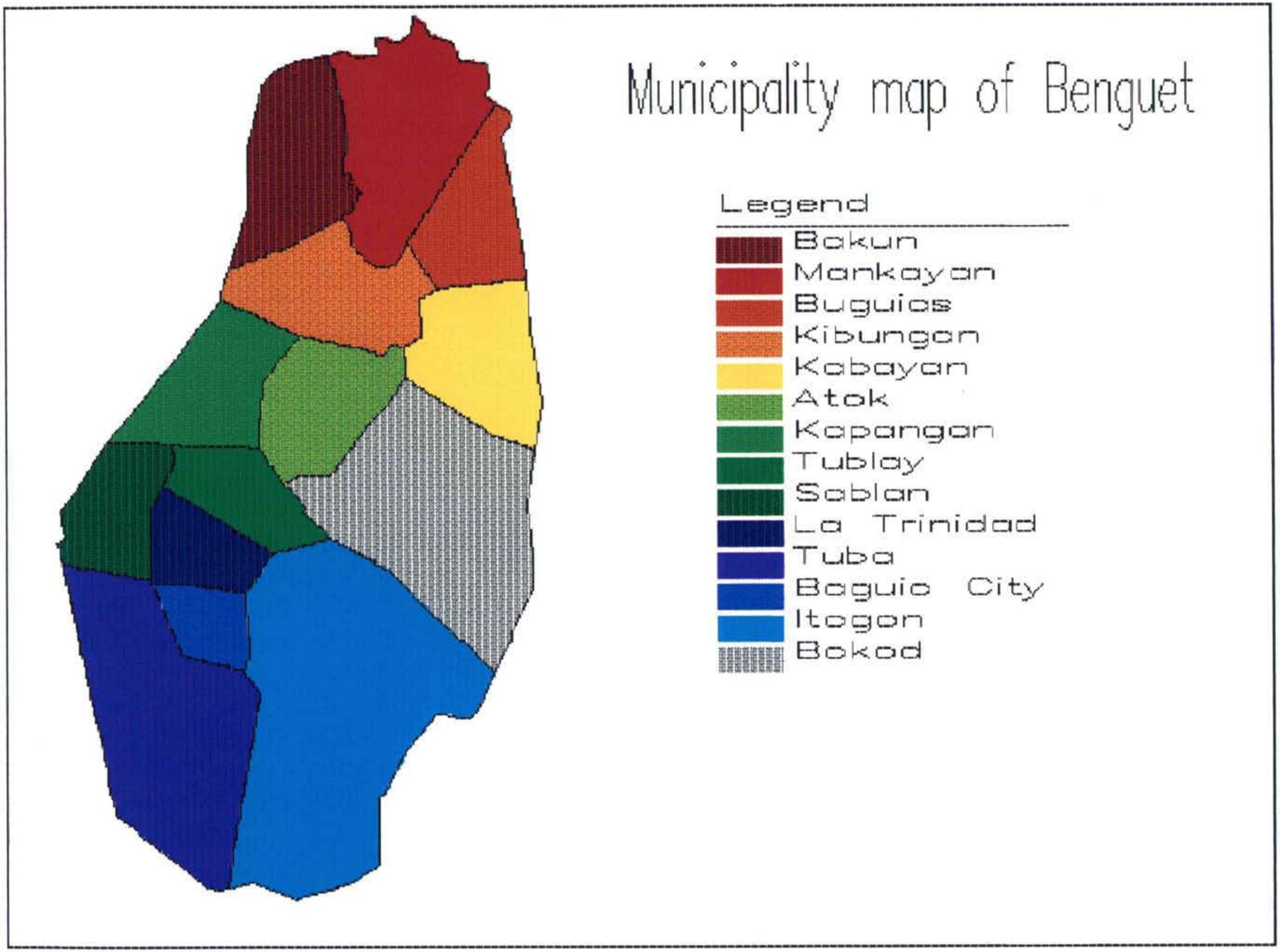
Land resource management and land use changes

The study area comprises 4 provinces, namely, Benguet, La Union, Pangasinan and Tarlac. The Agno River Basin is a a subset of the study area composed of 60 sub-basins. Land use patterns in the study area vary considerably with ricefield as the dominant land use comprising 3,654.2 km^2 (about 30%) of land area (Table 1). Dominant covers are grasslands (3,555.6 km^2 or about 29%) followed by forests with associated land uses (1,693.3 km^2 or about 14%). Forestlands with 90-100% forest cover comprised about 570.2 km^2 (4.7%) found mostly in the eastern part of Pangasinan and the western part of Tarlac bordering Zambales. Based on the 1990 survey of BSWM, only Pangasinan and Tarlac have areas with 90-100% forest cover, presumably composed of old growth dipterocarp. Within the Agno River Basin, dominant land use in the Tarlac-Zambales (S1 to S22 basins) area including the central plain (CP) is

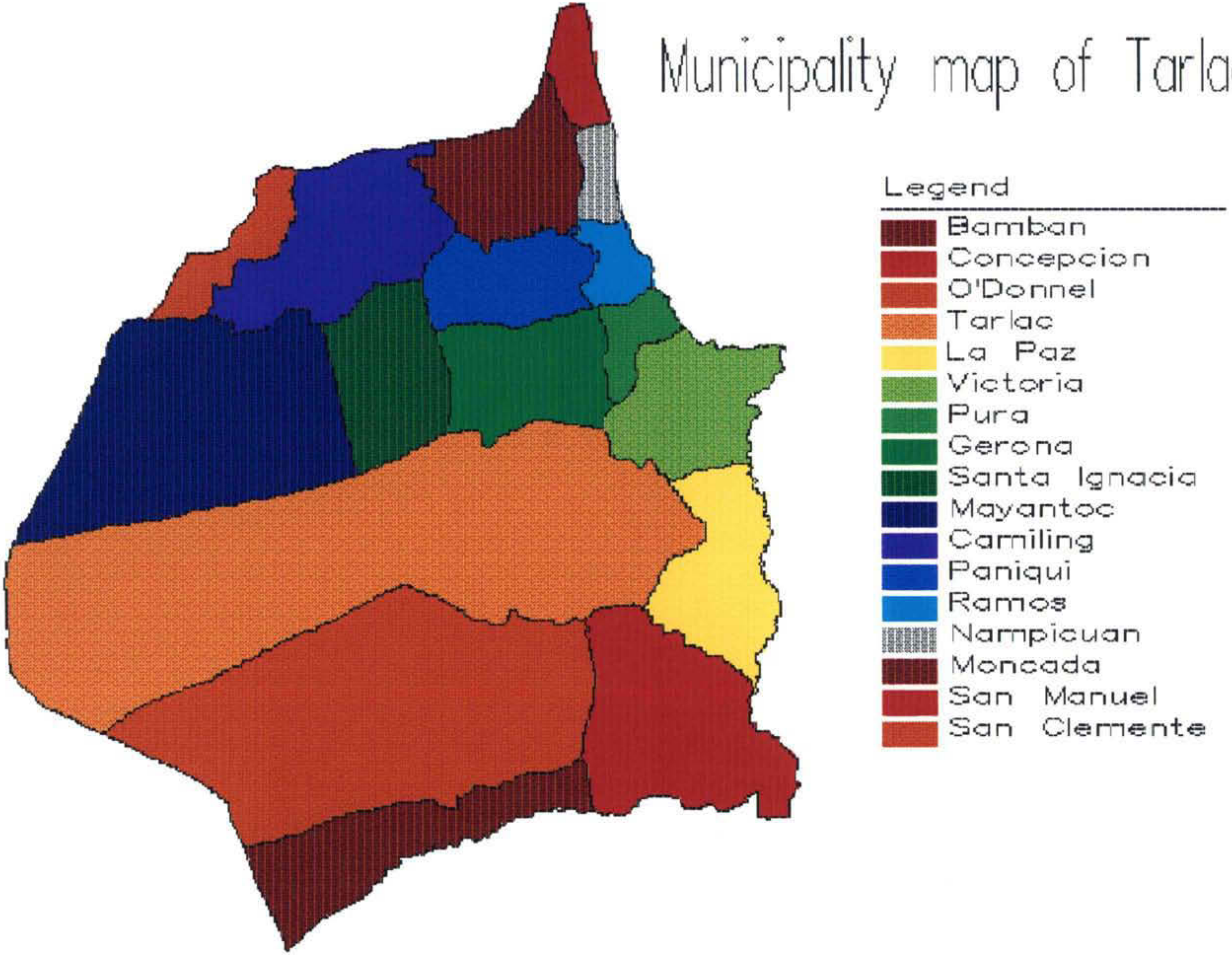

Municipality map of Pangasinan
------ Municipal Boundary

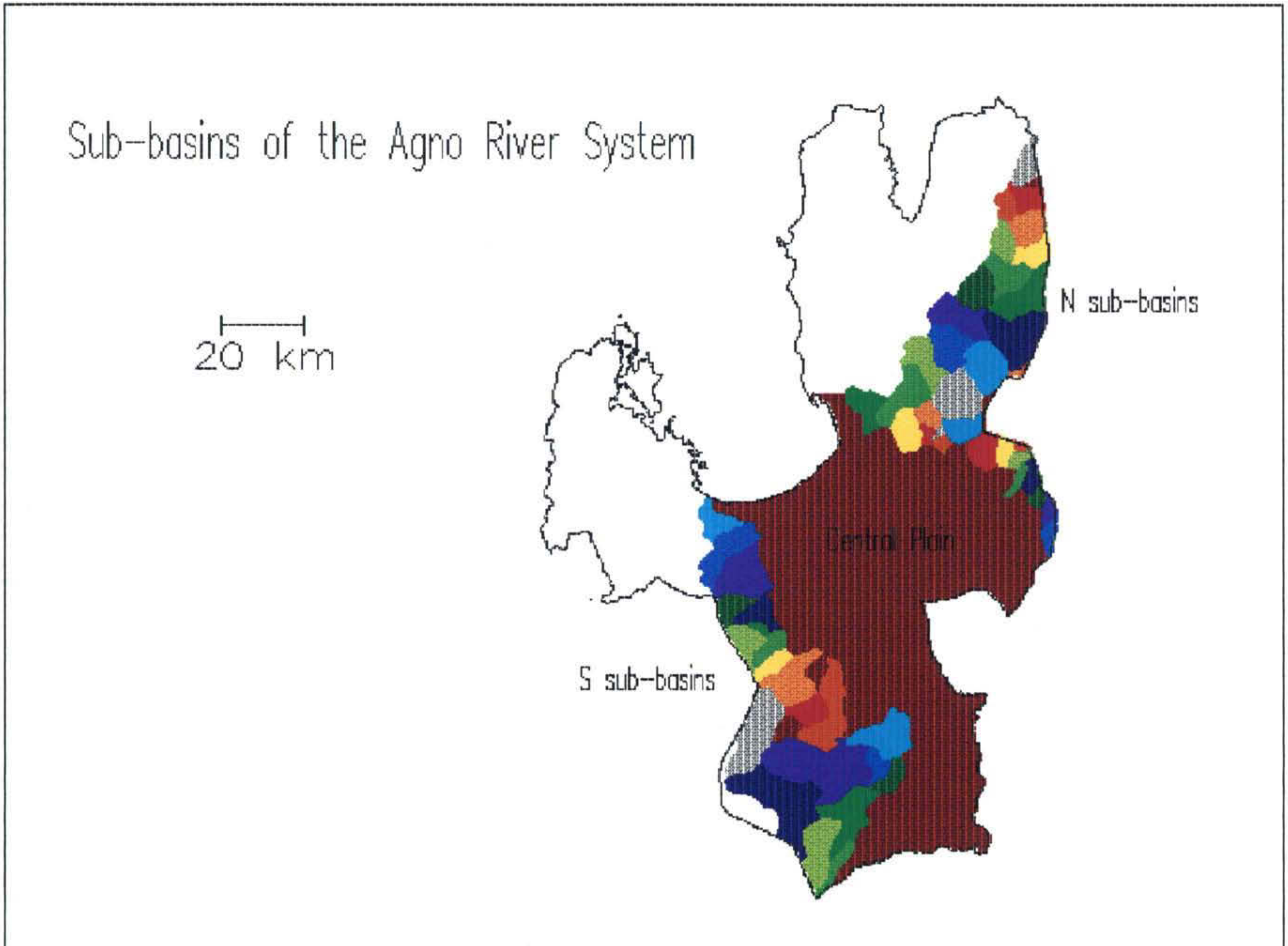
Municipality map of La Union




Municipality map of Benguet
Legend
Bakun
Mankayan
Buguias
Kibungan
Kabayan
Atok
Kapangan
Tublay
Sablan
La Trinidad
Tuba
Baguio City
Itogon
Bokod

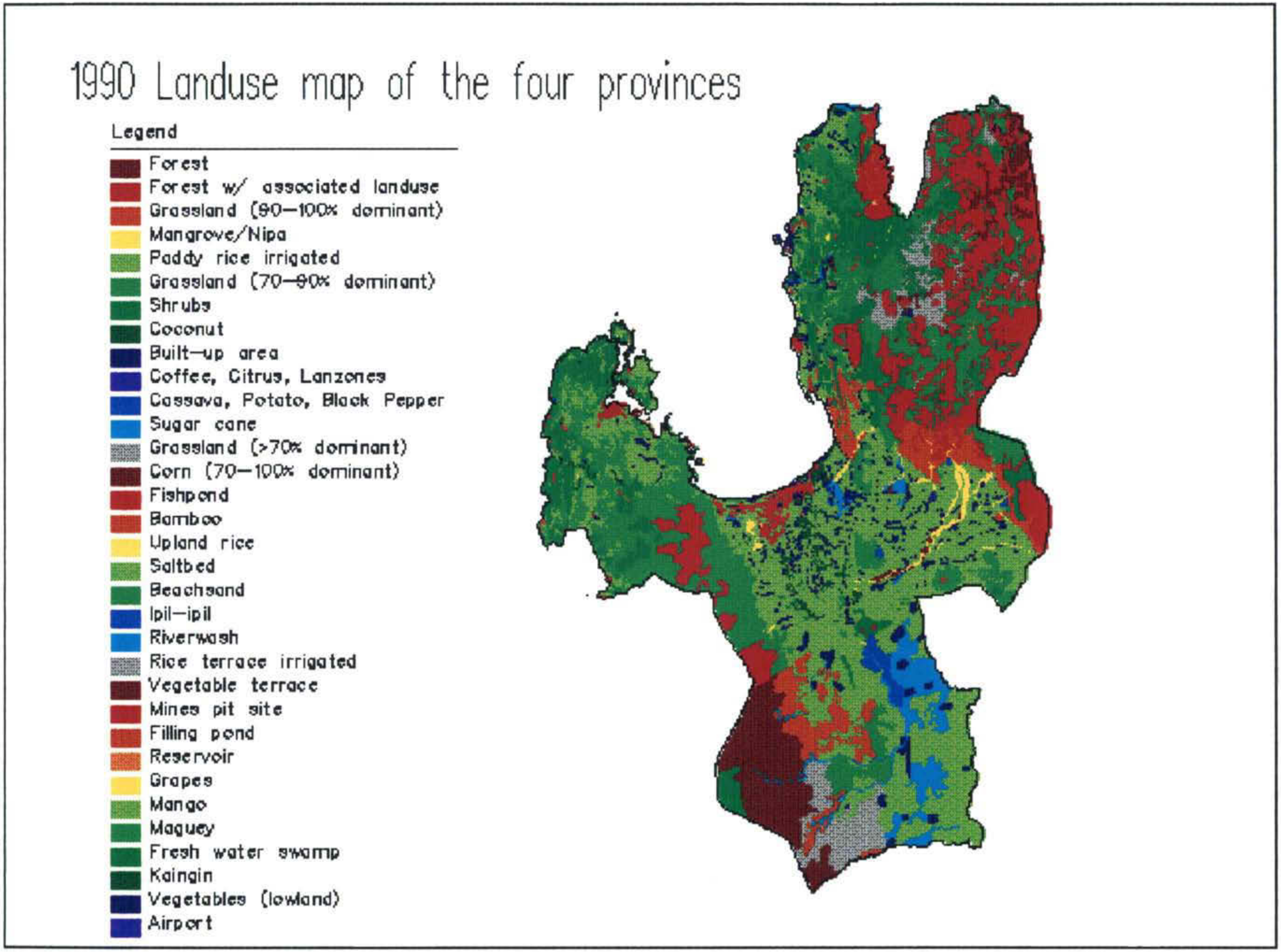
Municipality map of Tarlac




Sub-basins of the Agno River System
20 km
N sub-basins
Central Plain
S sub-basins

Area analysis of the 1990 land use map for Benguet, La Union, Pangasinan and Tarlac.

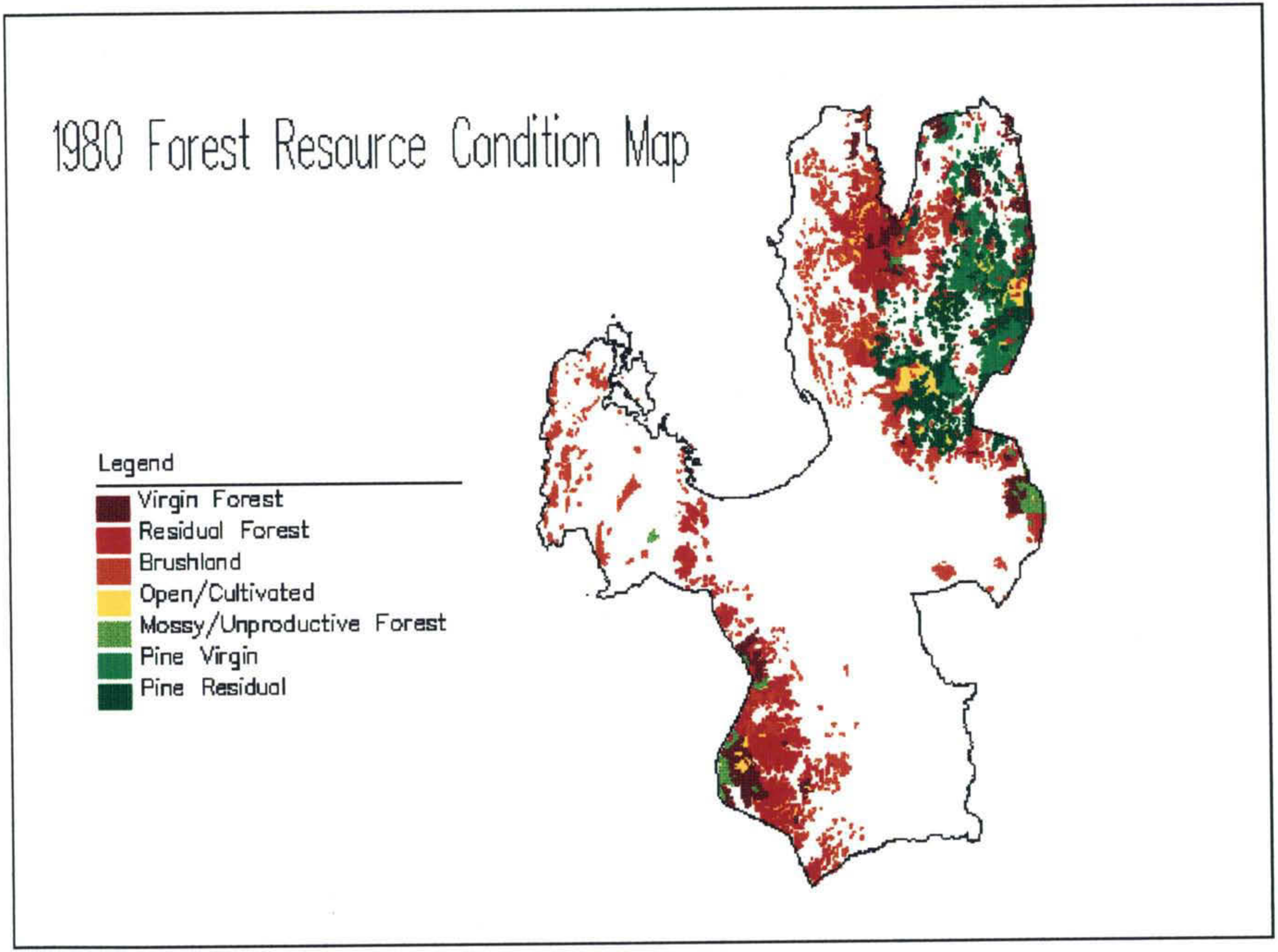
Clas	Land Use	Area (%)	Cumm	Area (km sq)
1	Forest	4.68	4.68	570.20
2	Forest w/ associated landuse	13.89	18.57	1,693.30
3	Grassland (90-100% dominant)	4.72	23.29	574.70
5	Mangrove/Nipa	0.11	23.40	13.87
6	Paddy rice irrigated	29.06	52.46	3,542.40
7	Grassland (70-90% dominant)	10.33	62.79	1,258.60
8	Shrubs	9.12	71.90	1,111.50
9	Coconut	1.09	73.99	132.50
10	Built-up area	3.47	76.46	423.00
11	Coffee, Citrus, Lanzones	0.02	76.48	2.30
12	Cassava, Potato, Black Pepper	0.73	77.21	88.59
13	Sugar cane	2.82	80.03	344.20
14	Grassland (<70% dominant)	14.13	94.16	1,722.30
15	Corn (70-100% dominant)	0.14	94.30	17.40
16	Fishpond	1.19	95.49	145.89
17	Bamboo	0.01	95.50	0.80
19	Upland rice	0.06	95.56	7.20
20	Saltbed	0.06	95.62	7.70
21	Beachsand	0.08	95.70	9.50
26	Ipil-ipil	0.01	95.71	1.30
27	Riverwash	1.74	97.45	211.54
28	Rice terrace irrigated	0.86	98.31	104.60
29	Vegetable terrace	1.24	99.55	151.70
30	Mines pit site	0.07	99.62	8.90
31	Filling pond	0.01	99.63	0.90
32	Reservoir	0.05	99.68	6.60
33	Grapes	0.01	99.69	0.90
34	Mango	0.04	99.73	5.10
35	Maguey	0.03	99.76	3.50
36	Fresh water swamp	0.12	99.88	15.20
37	Kaingin	0.01	99.89	0.50
38	Vegetables (lowland)	0.10	99.99	11.60
39	Airport	0.00	100.00	0.30
Total of 33 classes		100.00		12,188.59


1990 Landuse map of the four provinces
Legend
Forest
Forest w/ associated landuse
Grassland (90–100% dominant)
Mangrove/Nipa
Paddy rice irrigated
Grassland (70–90% dominant)
Shrubs
Coconut
Built–up area
Coffee, Citrus, Lanzones
Cassava, Potato, Black Pepper
Sugar cane
Grassland (>70% dominant)
Corn (70–100% dominant)
Fishpond
Bamboo
Upland rice
Saltbed
Beachsand
Ipil–ipil
Riverwash
Rice terrace irrigated
Vegetable terrace
Mines pit site
Filling pond
Reservoir
Grapes
Mango
Maguey
Fresh water swamp
Kaingin
Vegetables (lowland)
Airport

irrigated ricefields (2,808.41 km^2) and dominant cover is grassland/shrubs (1,410.31 km^2). In the Cordillera (N1 to N37 basins) area, forest with associated land uses has an aggregate area of 859.71 km^2 followed by grassland/shrubs (744.89 km^2). Forest can only be found in the Tarlac-Zambales and the central plain area (513.98 km^2).

In Benguet, extensive areas of forest with associated land uses occur but these are mostly consisted of grasses and shrubs. It is the second dominant land use/cover (1,169.19 km^2) after grasslands. Most of it are found in the municipalities of Itogon and Bokod. Grassland with 70-90% cover and shrubs are also extensive (1,278.26 km^2). In La Union, grassland/shrubs are the dominant land cover (808.94 km^2, 56%) followed by forest with associated landuses. This latter category is usually a mixed of agriculture and grass cover unlike that of Benguet. Both categories are extensive throughout hilly and/or mountainous municipalities like Aringay, Pugo, Tubao and Rosario. Agriculture is also significant (342.95 km^2, 23%) with ricefield as the most important and extensive. For Pangasinan, the dominant landuse is agriculture (2,352.06 km^2 , 46%) followed by grassland/shrubs (1,074.88 km^2, 21%). Within agriculture, ricefield comprised about 89% of total area and is extensive throughout the province. About 89.08 km^2 of old growth dipterocarp forests are found in the municipalities of Sison, Mangatarem, San Manuel and San Nicolas. In Tarlac, the dominant land use is irrigated ricefields (1,191.16 km^2, 39%) and are extensive through all municipalities. Old growth dipterocarp forest is the second dominant land use (562.83 km^2, 18%). Grassland and shrubs combined have an aggregate total of 774.39 km^2 or 25% of total provincial area but about 40% are located above 50 m elevation and >15% slope. Forest areas are located in the municipalities of Camp O'Donnell, Bamban, Mayantoc, Tarlac and San Clemente. Tarlac is known for its sugar cane production which covers 9% of total land area.

One of the issues affecting the basin is deforestation which resulted in soil erosion causing siltation of rivers and reservoirs (Ambuklao and Binga). In order to assess the extend of land use change with respect to forestlands, the 1981 forest resource condition map was evaluated against the 1990 land use/cover map. The 1981 forest resource condition map has the following categories: virgin forest (dipterocarp), residual forest (dipterocarp), brushland (grasslands and shrubs), mossy and unproductive forest (mostly dwarf trees), pine virgin forest, pine residual forest and open/cultivated (all categories not included elsewhere). Terminology used in the report differs from the maps. For example, closed and open pine forest referred to in the report are pine virgin and pine residual, respectively, in the forest resource condition map while submarginal forest is called unproductive forest. The virgin forest (dipterocarp) is distinguished into two categories-old growth above and below 800 m elevation. Residual forest generally refers to logged-over forest resulting from a selective logging system (i.e., Philippine Selective Logging System) (Hart 1989).


1980 Forest Resource Condition Map
Legend
Virgin Forest
Residual Forest
Brushland
Open/Cultivated
Mossy/Unproductive Forest
Pine Virgin
Pine Residual

The 1981 forest inventory.

Forest Cover	Forestlands	Certified A & D	Total (ha)	Total Dipterocarp	Total Pine	Total Brushland
BENGUET						
Dipterocarp						
Dipterocarp, residual	1,695	100	1,795	1,795		
Pine forest, closed	35,598	199	35,797		35,797	
Pine forest, open	56,438	1,197	57,635		57,635	
Submarginal forest	199		199			
Mossy forest	3,689		3,689			
Brushland	34,601	6,382	40,983			40,983
Total	132,220	7,878	140,098			
LA UNION						
Dipterocarp	389		389	389		
Dipterocarp, residual	875	778	1,653	2,431		
Pine forest, closed	195		195			195
Pine forest, open	1,070		1,070			1,070
Submarginal forest						
Mossy forest						
Brushland	17,800	28,889	46,689			46,689
Total	20,329	29,667	49,996			
PANGASINAN						
Dipterocarp	2,105		2,105	2,105		
Dipterocarp, residual	19,247	100	19,347	19,447		
Pine forest, closed	200		200		200	
Pine forest, open	902		902		902	
Submarginal forest	601		601			
Mossy forest	3,408		3,408			
Brushland	24,360	14,536	38,896			38,896
Total	50,823	14,636	65,459			

Forest Cover	Forestlands	Certified A & D	Total (ha)	Total Dipterocarp	Total Pine	Total Brushland
TARLAC						
Dipterocarp	6,390		6,390	6,390		
Dipterocarp, residual	30,012	290	30,302	30,592		
Pine forest, closed						
Pine forest, open						
Submarginal forest	774		774			
Mossy forest	3,776		3,776			
Brushland	9,681	1,936	11,617			11,617
Total	50,633	2,226	52,859			
Grand total	254,005	54,407	308,412	63,149	95,799	138,185

Kummer (1992) suggested that the major cause of *primary* forest denudation is logging both legal and illegal. The resulting condition paved the way for rapid conversion or modification. Such pattern may be evident in some of the dipterocarp forest modified into forest with associated land use category in the 1990 land use map. Other factors, however, may also played key roles

In the 1981 forest inventory project for Region I which included Abra, Ilocos Norte, Ilocos Sur and Mountain Province, the effective forest cover was about 22% (excluding brushlands) within forestlands (BFD 1987a). Dipterocarp forest were found mostly in Abra while pine forest were largely found in Benguet and Mountain Province. Within the study area, dipterocarp forest were mostly located in Tarlac bordering Zambales (Region III) (BFD 1987b). Estimated areal cover for dipterocarp (virgin and residual) was 119,484 ha (34.7%) while pine virgin and pine residual was 92,987 ha (27%). Table 2 shows the distribution of forest cover per province between forest lands and certified alienable and disposable lands (A & D) based on the forest inventory project. Area measurement for the total forest cover in the four provinces was higher by 16,894 ha in this present study, especially for dipterocarp (11% more than the report). The difference could be due to digitizing, delineation of the forest boundary during photointerpretation or in the transfer of data from aerial photographs and satellite images to maps as well as the fact that estimates were made at 1:50,000 scale whereas the digitized source maps were at 1:250,000 scales. Significant areas of closed and open pine forest existed in Benguet. Based on the 1981 inventory, closed pine forest (with >30% crown cover) was 35,598 ha while open pine forest (10-30% crown cover) was 56,438 ha which were lower than this study by 3%. The reasons for such discrepancy may be due to digitizing and the scale of the map used. The pine forest cover was patchy and small which may not have been fully captured during digitizing.

There are two types of land use/cover change - conversion and modification (Meyer and Turner 1992). Conversion refers to change into another category such as forest lands into agriculture areas while modification refers to change of conditions within the same category (i.e., rice to watermelons). Intensification is considered part of modification. With respect to conversion, a large part of the virgin forest was turned into grasslands/brushlands (13,989.7 ha or 31%) possibly through swidden agriculture although the immediate primary cause may be due to logging. Tarlac for example, has the highest relative conversion through logging in Region III (BFD 1987b). Modification into forestlands with associated land use (largely agriculture) comprised 17,591.3 ha (39%). Residual forests are typically logged-over with very minimal encroachment of agriculture or other activities. Within the basin, about 36,858.7 ha (43% of the total residual forest area) had been converted to brushland while 27,605.9 ha reverted back to forestland. Such afforestation was probably due to land abandonment which encouraged regrowth of trees. Substantial areas of

Assessment of land use change for Benguet cannot be equated with areas like Tarlac and Zambales. Benguet as in the case with other provinces in the Cordillera Autonomous Region (CAR) is basically a mountainous land where majority of settlements are located in high elevation and even in steep slopes. Generally, steeply sloped areas are referred to as uplands (World Bank 1989). In this case, one can loosely call Benguet as uplands. In contrast to provinces like Pangasinan and Tarlac, most settlements are located in the lowlands. In this latter situation, changes in the upland areas could be related to vertical migration (from lowland to upland) whereas in Benguet, land use changes could be attributed to lateral expansion of economic and demographic activities as well because historically, people have been living in these areas. No attempt was made to assess land use pattern in Benguet with respect to demographic pressure.

Soil erosion and nonpoint pollution critical areas

Soil erosion is the gross amount of soil detached and transported by either water or wind. The extent of soil erosion is affected by several factors including slope, rainfall pattern and land use practices (Mitchell and Bubenzer 1980). According to World Bank (1989), soil erosion is generally ranked as the most serious environmental problem in the Philippines because more than half of the land is over 18% slope. Soil erosion in the Agno River Basin is a significant concern in terms of agriculture, water resource development and forest conservation. Quantitative estimation, however, is limited such as those conducted on flood control by the JICA/DPWH (1991)[3]. The method used was based on estimating the sediment yield of some land use parameters (forest, bare lands and land fall/slide) taken from 1980-1981 aerial photographs. The study showed that average sediment yield for the Cordillera sub-basins is 18.5 million m^3/year (29.6 million t/year) while the Tarlac-Zambales sub-basins is 14.4 million m^3/year (23.04 million t/year). A UNDP/NWRC study reported that 50% of the basin is susceptible to erosion but no sediment yield estimate was given (NWRC 1983).

In this study, soil erosion is quantified using the Universal Soil Loss Equation (USLE) which is an empirical model (McElroy et al. 1976). Although some of the parameters are location specific, the USLE has been used in different

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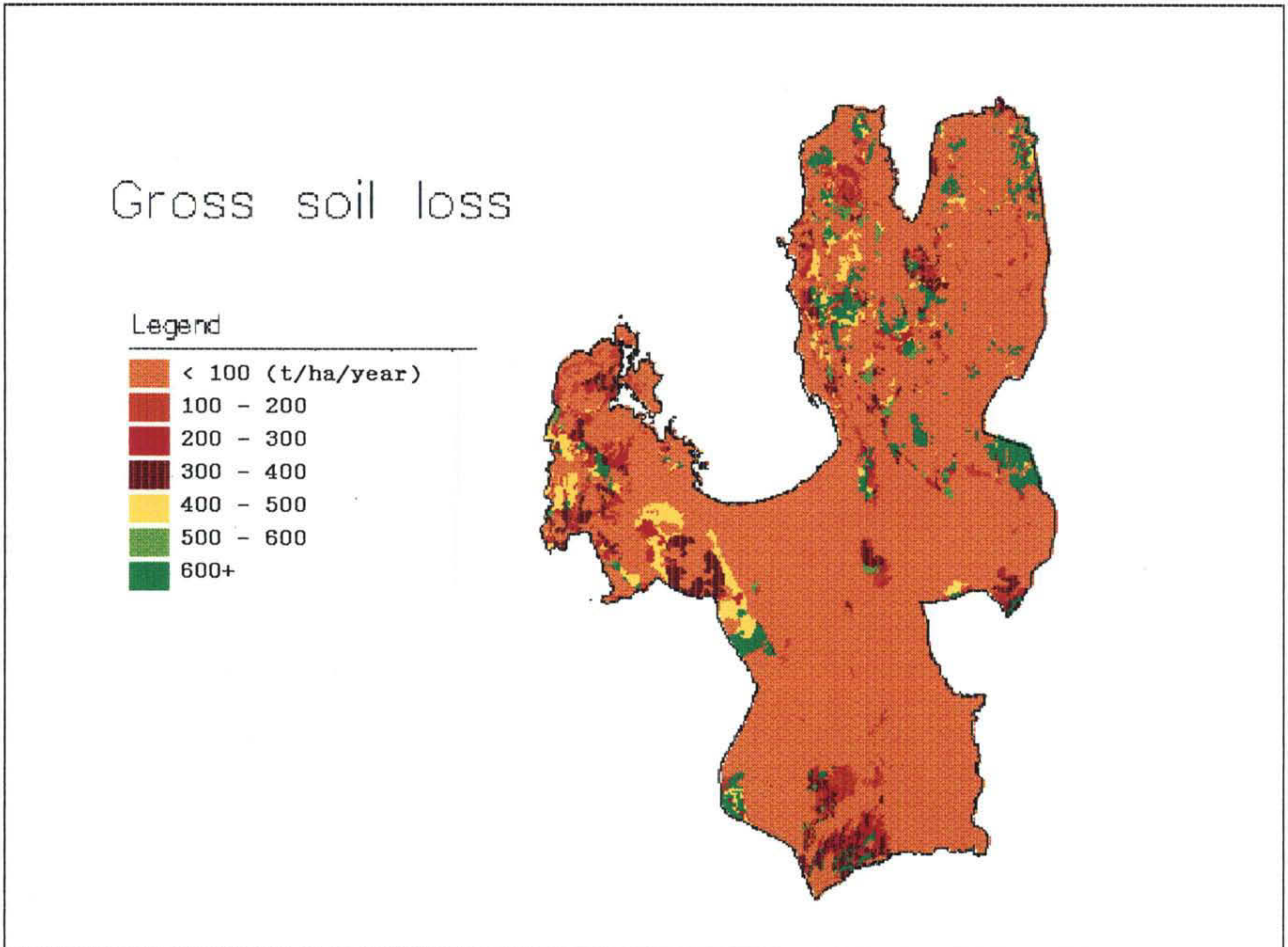
3 There are several studies on soil loss estimation for Benguet and La Union as graduate theses/dissertations at the University of the Philippines in Los Baños, Laguna and Benguet State University (formerly Mountain State Agricultural College) as well as reports by the Environment Research and Development Bureau (formerly Forest Research Institute). Assessment of these reports/papers is yet to be made for re-estimation/validation of the USLE parameters for Benguet and La Union.

parts of the world under various climatic and land cover conditions with varying success (Mitchell and Bubenzer 1980, World Bank 1989). In the Philippines, the USLE has been used in small watersheds like the Magat and Pantabangan watersheds. This study draws extensively from the works of David (1987) and David and Collado (n.d.), particularly in the estimation of the slope-length factor (LS), cropping (C) and management (P) factors, although validation of the results is yet to be made. For the whole four provinces, only gross soil loss was estimated. Sediment yield was calculated for the Agno River Basin only since only the basin's sediment delivery ratio which is that portion of eroded soil delivered into the receptor water, was determined. The gross soil loss and sediment yield of the Agno River Basin are found in tables annexed to this report. Also, gross soil loss across slopes, elevation, land use and the municipalities of Benguet, La Union, Pangasinan and Tarlac are in tables annexed to this report. The sediment yield is compared to the JICA/DPWH (1991) study as shown in Table 4.

Gross soil loss estimate of the 59 sub-basins ranged from 6.62 to 5,143.90 t/ha/year. For sediment yield, it ranged from 181 to 23,779,454 t/year. The basin with the lowest soil loss and sediment yield are N26 and N19, respectively. The latter has low drainage density and consisted only of two land use categories - forest with associated land uses (typically grasslands) and grassland (70-90% dominant). Some of the sub-basins with highest sediment yield are about the same as those in the JICA/DPWH (1991) report. Basin N1 has the highest gross soil loss while highest sediment yield is S6. It is possible that the contributing factor in basin N1 is the presence of vegetable terrace (3,754 ha). Area cross tabulation between gross soil loss and land use showed that about 4,820 ha of vegetable terrace have gross soil loss >500 t/ha/year. Also, about 9,347 ha of vegetable terrace are located at >40% slope and $\geq$800 m elevation. Basin S6 is located in Tarlac, Tarlac and a dam (Balog Balog) is under construction in its upper watershed (JICA/DPWH 1991). Possible contributing factors to the high sediment yield in Basin S6 in terms of land use are the dominance of grasslands (<90% dominant) at 9.093 ha, ricefield (3,779) ha and riverwash (1,144 ha). Drainage density is relatively high. In contrast with Benguet, grasslands in Tarlac are mixed of agriculture and other land uses. Agriculture in grasslands is typically seasonal such as rice cultivation.

By land use category within the study area, grassland (<70% dominant) has the highest total gross soil loss at 58,936 t/ha/year with a total area of 172,230 ha (14.12% of the study area). Vegetable terraces has total gross soil loss of 22,491.52 t/ha/year but the total area is only 15,170 ha (1.24% of study area). These are located in Benguet at steep slopes and high elevation. This shows that conservation practices may be inadequate.

Slope, loss of vegetable cover, poor conservation practice and high drainage density contribute to soil erosion. Typically, municipalities with


Gross soil loss
Legend
< 100 (t/ha/year)
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600+

Comparison of the sediment yield between JICA/DPWH (1991) and GISCAMP.

Basin	(JICA) Area (Km^2) [A]	(JICA) Sediment Rate ($m^3/km^2/yr$) [B]	(JICA) Yield (t/yr) [C]	(GISCAMP) Yield (t/yr) [D]
S1	119	12,143	2,312,027.20	12,795,579
S2	39	15,157	945,796.80	2,418,824
S3	121	5,474	1,059,766.40	3,355,055
S4	29	1,300	60,320.00	474,138
S5	283	9,469	4,287,563.20	18,576,929
S6	254	8,207	3,335,324.80	23,779,454
S7	34	1,432	77,900.80	196,821
S8	138	1,316	290,572.80	1,945,451
S9	221	6,400	2,263,040.00	472,292
S10	20	5,208	166,656.00	86,482
S11	42	2,907	122,094.00	562,590
S12	190	3,066	932,064.00	154,996
S13	105	5,147	864,696.00	823,190
S14	146	7,898	1,844,972.80	1,121,674
S15	130	10,738	2,233,504.00	2,858,580
S16	21	13,100	440,160.00	1,003,273
S17	43	13,367	919,649.60	133,112
S18	64	11,925	1,221,120.00	361,941
S19	8	2,657	34,009.60	435,974
S20	54	4,448	384,307.20	3,791,939
S21	72	3,782	435,686.40	1,126,179
S22	129	4,351	898,046.40	291,691
N1	48	4,208	323,174.40	280,137
N2	56	2,510	224,896.00	39,981
N3	60	6,750	648,000.00	4,530,272
N4	33	3,471	183,268.80	1,868,165
N5	55	5,457	480,216.00	5,672,829
N6	68	5,995	652,256.00	1,003,111
N7	41	5,422	355,683.20	1,075,623
N8	72	6,469	745,228.80	904,370
N9	103	4,660	767,968.00	1,432,449
N10	81	7,429	962,798.40	315,159
N11	143	6,076	1,390,188.80	4,234,534
N12	100	10,557	1,689,120.00	5,645,541
N13	80	6,627	848,256.00	5,305,839
N14	111	28,280	5,022,528.00	4,915,615
N15	94	4,361	655,894.40	89,630
N16	105	9,779	1,642,872.00	13,627
N17	85	4,785	650,760.00	1,983,180
N18	151	8,803	2,126,804.80	9,257
N19	119	18,107	3,447,572.80	181
N20	40	14,587	933,568.00	1,415,762
N21	53	15,322	1,299,305.60	223,974

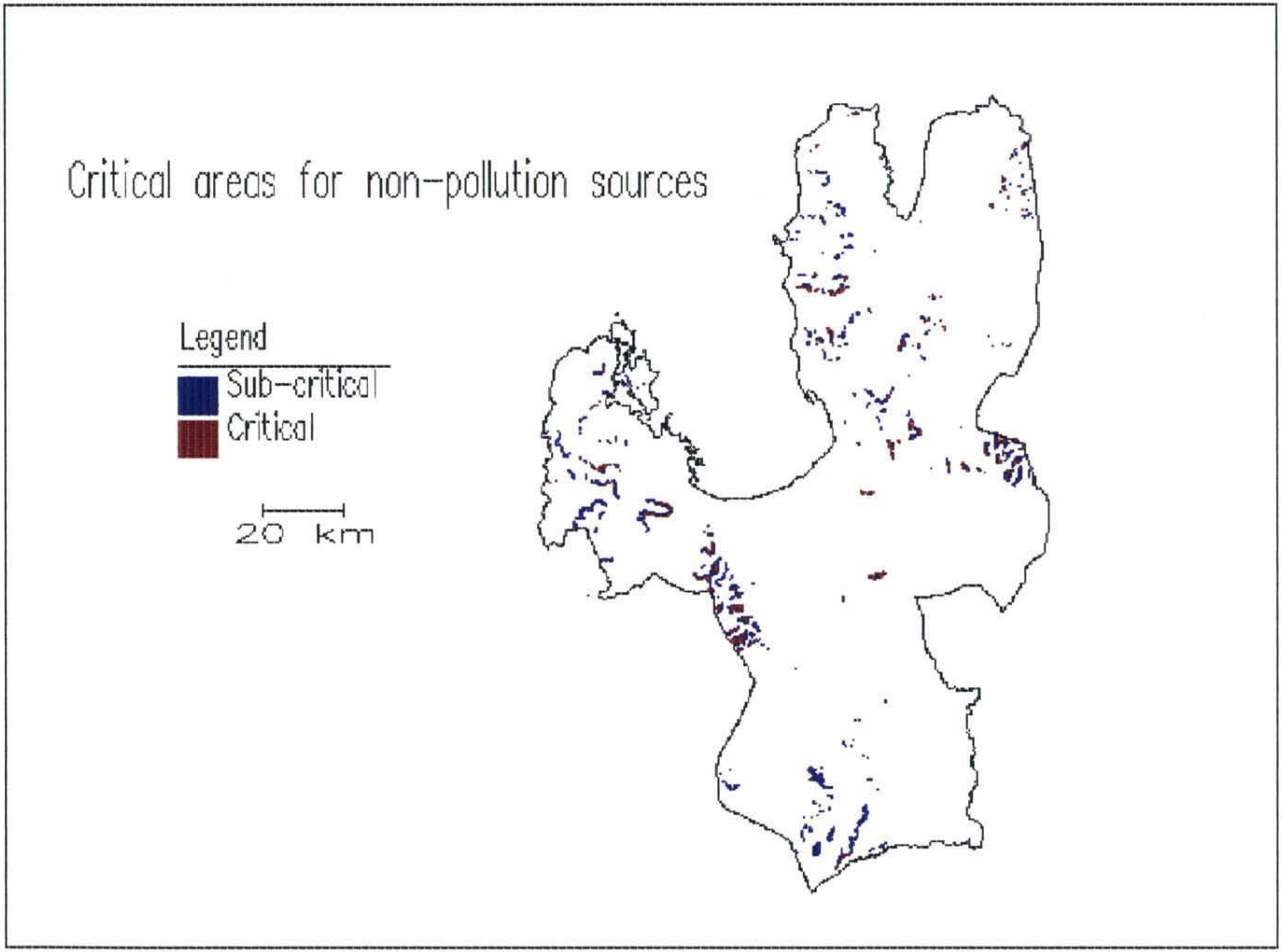
Basin	(JICA) Area (Km^2) [A]	(JICA) Sediment Rate ($m^3/km^2/yr$) [B]	(JICA) Yield (t/yr) [C]	(GISCAMP) Yield (t/yr) [D]
N22	50	3,086	246,880.00	502,452
N23	39	3,510	219,024.00	9,571
N24	29	6,815	316,216.00	53,486
N25	69	6,082	671,452.80	1,664,390
N26	73	5,895	688,536.00	6,929
N27	93	3,245	482,856.00	64,711
N28	75	7,964	955,680.00	356,165
N29	15	8,083	193,992.00	16,452
N30	16	3,070	78,592.00	303,748
N31	21	5,148	172,972.80	852,881
N32	66	4,289	452,918.40	274,526
N33	66	2,174	229,574.40	151,817
N34	44	3,102	218,380.80	9,948,910
N35	80	4,501	576,128.00	8,026,761
N36	102	4,621	754,147.20	8,351,755
N37	67	3,654	391,708.80	7,610,679

Note: [C] = [A] x [B] x 1.6 t/m^3 (weight of sediment) rugged terrain have high gross soil loss. Municipalities with total gross soil loss of >4,000 t/ha/year per province are: Pangasinan - Bani, Anda, Dasol, Infanta, Mangatarem, Sison and San Manuel; Benguet - Mankayan, Buguias, Tublay, La Trinidad, Tuba, Itogon and Bobok; La Union - Agoo, Tubao and Naguilian; and Tarlac - Bamban, O'Donnell and Tarlac. Municipalities with over 7,000 t/ha/year soil loss are Mankayan, Bokod, Agoo, Bamban and O'Donnell.

The values of the USLE parameters used in this study have not been validated. At best, the results give a rough estimates on the soil loss associated with rill and sheet erosion. Comparison with the JICA/DPWH (1991) showed that sediment yield (t/ha/year) results of the 59 sub-basins in this study are much higher. Difference between the two studies' means is highly significant. Apart from the difference in methodology, there is about ten years difference on the land cover used by both studies. Comparison with the sediment yield for 10 sub-basins that drains into the Ambuklao Dam, the result of this study is three times that of JICA/DPWH (1991). This study, therefore, recommends the reassessment of the soil erosion profile of the Agno River Basin, particularly in the refinement of the soil erodibility index (K) and vegetation cover factor (C) so that there will be a basis of refining existing water and land resources (e.g., reforestation) programs.

Pollution from nonpoint sources requires some flexible approach in management (Sivertun et al. 1988). Most pollutants from such sources are suspended sediments, nitrogen, phosphorus and agricultural runoffs. To some extend, nonpoint pollution sources are difficult to contain because they can be everywhere. By targeting critical areas, it is possible to optimize water quality improvement. Critical areas refers to potential areas that will have significantly higher contribution to pollution than other areas and are usually located at steep slope and within proximity to water sources (Reinelt et al. 1989). Sub-critical areas, on the other hand, can contribute to pollution loading, especially when significant land use changes take place, particularly intensification and conversion. This study conducted map modelling using some of the parameters of the USLE. No validation of the results has been conducted and therefore, the findings must be interpreted as rough indications of nonpollution sources. Tables on area and area cross tabulation with land use, erosion, slope, elevation and municipality are annexed to this report. A summary of the findings is given below.

In this study, critical areas in the Agno Basin has an aggregate of 11,190 ha while sub-critical areas comprised about 30,740 ha. About 83% and 66% of the critical and sub-critical areas, respectively, are located above 15% slope category and >150 m elevation. About 76% and 77% of the critical and sub-critical areas, respectively, are found within lands categorized by the BSWM having moderate to very erosion. Suspended sediment due to soil erosion is among the important pollutants from nonpoint sources in the Agno River Basin (about 60% of the



Critical areas for non-pollution sources
Legend
Sub-critical
Critical
20 km

critical areas are located within the basin). By land use categories, critical and sub-critical areas have the following areal extent:

Land Use	Critical	Sub-critical
Grasslands (<90% dominant)	7,650 ha	19,650 ha
Shrubs	330 ha	6,190 ha
Ricefields	1,960 ha	2,780 ha
Vegetable terrace	780 ha	1,200 ha

Major critical and sub-critical areas within the municipalities of Benguet, La Union, Pangasinan and Tarlac by hectarage are:

Municipality	Critical	Sub-critical
Buguias	542 ha	962 ha
Tuba	415 ha	1,548 ha
Bauang	360 ha	388 ha
Aringay	411 ha	1,055 ha
Naguilian	515 ha	733 ha
Mabini	1,171 ha	1,673 ha
Bugallon	514 ha	1,434 ha
Aguilar	589 ha	1,177 ha
Mangatarem	913 ha	1,639 ha
Sison	324 ha	372 ha
San Nicolas	1,309 ha	2,496 ha
Bamban	212 ha	958 ha
O'Donnell	102 ha	3,136 ha
Tarlac	28 ha	1,682 ha

The land use under most of the critical and sub-critical areas are grasslands with slope >15% and ricefields except for Buguias with its extensive vegetable terraces. This indicates that any unplanned or unmanaged activities which could result in conversion or significant modification will increase and/or enhance pollutant loading into the receptor waters. The municipalities with substantial critical and sub-critical areas have some rugged or hilly topography in addition to high drainage density. Moreover, some of the abovementioned municipalities showed high gross soil loss. Thus, significant land use change in these municipalities, particularly in areas of steep slopes will have an impact on surface water quality. Although assessment is needed to determine the detailed spatial characteristics of these areas relative to slope, land use and municipal jurisdiction, it will suffice to infer from the results that any form of conversion or modification should be allowed only with proper environmental consideration.

Implications of this study

Land use change in the study area has been extensive, particularly with forestlands. Although reforestation projects are ongoing (JICA/DPWH 1991), areas so far covered are not extensive. Of the 39 ongoing/existing reforestation projects with an aggregate total area of 76,394.5 ha, only-2,793 ha had been planted as of 1989. The same report estimated that 50% of the sediment yield within Agno River Basin can be controlled through reforestation equivalent to an area of about 100,000 ha. There are also rehabilitation of the watershed and erosion control projects within the whole length of the basin. To date, there are 14 projects ongoing or completed. In this study, conversion of forestland into brushland and agriculture is significant. Thus, reforestation should also target those areas which had been converted to brushlands. For agriculture areas which are in forestlands (i.e., public domain), efforts must be made to stop farming and introduce social forestry program, instead.

Mining is an important economic sector, especially for Benguet (Briones 1987). The discharge of mine tailings have severely affected lowland areas. Although filling ponds and control measures have been emplaced, mining tailings from previous discharges are now widespread in the gulf, particularly along the rivermouth of Agno River in Lingayen and Pantalan-Sinocalan Rivers. The beach strip on both sides of the Agno River showed pyritic floats sometimes as thick as 3 mm. Long-term impact of these tailings remains to be assessed.

With respect to soil loss, the results of this study can only be taken as rough indications of the effect of existing land use patterns on soil management. Soil loss is significant in areas with poor conservation practices, especially agriculture in steep slopes such as vegetable terrace and seasonal croppings. About twenty municipalities in the four provinces showed >4,000 t/ha/year total gross soil loss. In areas with high gross soil loss as well as in nonpoint pollution critical and sub-critical areas, significant land use change (i.e., conversion, modification and intensification) will have impact on surface water quality as well as increase sediment loading into the river systems and eventually, the Lingayen Gulf. The study area has extensive grasslands of varying percentage cover. Conversion or modifications of these areas must conform to the provisions under Presidential Proclamation 2146[4] so that negative environmental impact can be minimized.

Evaluating the findings of this study relative to the Lingayen Gulf coastal areas has important implications. Unregulated activities in the uplands, especially associated with mining are affecting the water quality of the gulf as

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4 Proclaims certain areas and types of projects as environmentally critical and within the scope of an environmental impact statement.

well as surface waters draining into the Pangasinan plain. Siltation and flooding frequently occur during rainy seasons due to soil erosion and inadequate flood control measures both in the uplands and lowlands. Land use change in the lowlands, in this case, the coastal and adjacent municipalities of La Union and Pangasinan will significantly increase sediment and pollution load into the gulf. Given the industrialization program within the two provinces, it is necessary to undertaken environmental impact assessment on all large-scale projects earmarked for the areas, especially those with polluting effects. Since the Lingayen Gulf has been declared as an environmentally critical area by Presidential Proclamation (PP) 156 dated 25 March 1993, it is but crucial to enforce the provisions of PP 2146 for any developments within the Agno River Basin and the lowlands of La Union and Pangasinan.

Conclusion

This study assessed land use pattern and change within the provinces of Benguet, La Union, Pangasinan and Tarlac. Forest cover has been significantly reduced since the inventory conducted in 1980-1981. Conversion to brushland and agriculture were the major proximate causes although logging under the Philippine Selecting Logging System was the primary cause. Several reforestation projects including watershed rehabilitation and erosion control projects are either ongoing or completed but so far, areal extent is not extensive. Existing land use pattern showed that there is significant encroachment of agriculture into forestlands (>25% slope). These are found in Benguet (20,018 ha), Pangasinan (9,784 ha) and La Union (8,506 ha).

Soil erosion is one of the major environmental problems affecting the Agno River Basin as a result of vegetation cover loss, inadequate conservation practice in agricultural areas and conversion to other land uses. Although the result of this study requires validation, significant gross soil loss (>4,000 t/ha/year) occurred in twenty municipalities of the study area. Nonpoint pollution source areas with critical and sub-critical categories are located in fourteen municipalities. Most of these municipalities have rugged terrain. In terms of land use patterns, areas with high gross soil loss are grassland with varying percentage of vegetation cover and agricultural areas (ricefield and vegetable terraces). Similarly, land use patterns have been noted in areas under critical and sub-critical categories for nonpoint pollution. Conversion or modification including intensification of these areas can exacerbate present environmental problems unless adequate regulatory measures are followed including enforcement of thereof.

It is recommended that a reassessment of the soil erosion profile of the four provinces, especially the Agno River Basin be undertaken as well as the refinement of the USLE parameters under local conditions.

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Tables on single area and

area cross tabulation analysis

for 1990 Land use/cover

Area cross tabulation of the 1990 land use map in the municipalities of Pangasinan (Part I).

Area (km sq.)
Total %
Row %
Col %

Land Use	San Fabian	Mangaldan	Dagupan	Calasiao	Binmaley
Forest with associated land uses	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
Grassland (>90% dominant)	30.97	0.00	0.00	0.00	0.00
	3.33	0.00	0.00	0.00	0.00
	92.30	0.00	0.00	0.00	0.00
	41.15	0.00	0.00	0.00	0.00
Mangroves/nipa	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
Ricefield, irrigated	25.16	19.14	11.41	32.83	17.69
	2.71	2.06	1.23	3.53	1.90
	6.31	4.80	2.86	8.24	4.44
	33.43	41.89	22.52	61.71	36.80
Grassland (70-90% dominant)	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
Shrubs	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
Coconut	5.02	7.68	6.65	12.79	0.00
	0.54	0.83	0.71	1.38	0.00
	9.32	14.25	12.34	23.74	0.00
	6.67	16.81	13.12	24.03	0.00
Built-up Areas	6.96	8.32	7.01	6.14	2.03
	0.75	0.89	0.75	0.66	0.22
	9.63	11.51	9.69	8.49	2.81
	9.25	18.21	13.83	11.54	4.23

Land Use	San Fabian	Mangaldan	Dagupan	Calasiao	Binmaley
Sugar cane	0.00	7.69	0.00	0.00	0.00
	0.00	0.83	0.00	0.00	0.00
	0.00	45.41	0.00	0.00	0.00
	0.00	16.84	0.00	0.00	0.00
Grassland (<70%	0.72	0.00	0.00	0.00	0.00
dominant)	0.08	0.00	0.00	0.00	0.00
	0.40	0.00	0.00	0.00	0.00
	0.95	0.00	0.00	0.00	0.00
Fishponds	0.55	1.91	25.41	1.32	28.22
	0.06	0.21	2.73	0.14	3.04
	0.57	1.98	26.29	1.36	29.20
	0.73	4.19	50.15	2.47	58.72
Beach sand	0.11	0.00	0.19	0.00	0.12
	0.01	0.00	0.02	0.00	0.01
	2.62	0.00	4.87	0.00	3.00
	0.14	0.00	0.38	0.00	0.25
Riverwash	5.78	0.94	0.00	0.00	0.00
	0.62	0.10	0.00	0.00	0.00
	84.31	13.73	0.00	0.00	0.00
	7.68	2.06	0.00	0.00	0.00
Freshwater swamps	0.00	0.00	0.00	0.13	0.00
	0.00	0.00	0.00	0.01	0.00
	0.00	0.00	0.00	7.89	0.00
	0.00	0.00	0.00	0.25	0.00
Total	75.26	45.68	50.67	53.21	48.06
	8.09	4.91	5.45	5.72	5.17

Land Use	San Carlos	Lingayen	Labrador	Sual	Alaminos	Total
Forest with associated land uses	0.00	0.00	40.89	0.67	0.00	41.56
	0.00	0.00	4.40	0.07	0.00	4.47
	0.00	0.00	98.38	1.62	0.00	
	0.00	0.00	35.98	0.46	0.00	
Grassland (>90% dominant)	0.00	0.00	0.00	2.58	0.00	33.55
	0.00	0.00	0.00	0.28	0.00	3.61
	0.00	0.00	0.00	7.70	0.00	
	0.00	0.00	0.00	1.78	0.00	
Mangroves/nipa	3.06	2.85	0.00	0.00	0.00	5.92
	0.33	0.31	0.00	0.00	0.00	0.64
	51.77	48.23	0.00	0.00	0.00	
	1.72	4.78	0.00	0.00	0.00	
Ricefield, irrigated	115.43	28.67	13.91	41.32	92.83	398.37
	12.42	3.08	1.50	4.44	9.98	42.85
	28.97	7.20	3.49	10.37	23.30	
	64.95	48.00	12.24	28.47	57.78	
Grassland (70-90% dominant)	0.00	0.00	0.00	5.47	10.50	15.97
	0.00	0.00	0.00	0.59	1.13	1.72
	0.00	0.00	0.00	34.24	65.76	
	0.00	0.00	0.00	3.77	6.54	
Shrubs	0.00	0.00	0.00	0.96	2.55	3.51
	0.00	0.00	0.00	0.10	0.27	0.38
	0.00	0.00	0.00	27.23	72.77	
	0.00	0.00	0.00	0.66	1.59	
Coconut	20.09	0.00	0.67	0.97	0.00	53.87
	2.16	0.00	0.07	0.10	0.00	5.79
	37.30	0.00	1.25	1.80	0.00	
	11.31	0.00	0.59	0.67	0.00	
Built-up Areas	27.83	5.41	0.00	2.15	6.45	72.30
	2.99	0.58	0.00	0.23	0.69	7.78
	38.49	7.48	0.00	2.98	8.93	
	15.66	9.05	0.00	1.48	4.02	
Sugar cane	0.00	0.67	0.24	8.25	0.09	16.94
	0.00	0.07	0.03	0.89	0.01	1.82
	0.00	3.97	1.41	48.68	0.53	
	0.00	1.13	0.21	5.68	0.06	
Grassland (<70% dominant)	0.00	0.00	54.88	82.07	40.89	178.56
	0.00	0.00	5.90	8.83	4.40	19.21
	0.00	0.00	30.74	45.96	22.90	
	0.00	0.00	48.30	56.55	25.45	

Land Use	San Carlos	Lingayen	Labrador	Sual	Alaminos	Total
Fishponds	9.61	18.55	3.05	0.69	7.34	96.64
	1.03	2.00	0.33	0.07	0.79	10.39
	9.94	19.20	3.15	0.71	7.59	
	5.40	31.07	2.68	0.47	4.57	
Beach sand	0.00	3.57	0.00	0.00	0.00	3.99
	0.00	0.38	0.00	0.00	0.00	0.43
	0.00	89.51	0.00	0.00	0.00	
	0.00	5.98	0.00	0.00	0.00	
Riverwash	0.13	0.00	0.00	0.00	0.00	6.86
	0.01	0.00	0.00	0.00	0.00	0.74
	1.96	0.00	0.00	0.00	0.00	
	0.08	0.00	0.00	0.00	0.00	
Freshwater swamps	1.57	0.00	0.00	0.00	0.00	1.70
	0.17	0.00	0.00	0.00	0.00	0.18
	92.11	0.00	0.00	0.00	0.00	
	0.88	0.00	0.00	0.00	0.00	
Total	177.72	59.72	113.64	145.13	160.65	929.73
	19.12	6.42	12.22	15.61	17.28	

Area cross tabulation of the 1990 land use map for the municipalities of Pangasinan (Part II).

Area (km sq.)
Total %
Row %
Col %

Land Use	Bani	Bolinao	Anda	Santiago	Siapar Island	Hundred Islands	Cabalitian Island	Agno	Burgos	Total
Grassland (>90% dominant)	5.12	0.00	0.00	0.00	0.00	0.00	0.00	1.81	1.90	8.83
	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.26	1.19
	58.04	0.00	0.00	0.00	0.00	0.00	0.00	20.47	21.49	
	2.35	0.00	0.00	0.00	0.00	0.00	0.00	1.30	1.54	
Mangroves/nipa	0.00	0.40	0.00	1.43	0.00	0.00	0.00	0.42	0.00	2.26
	0.00	0.05	0.00	0.19	0.00	0.00	0.00	0.06	0.00	0.30
	0.00	17.88	0.00	63.58	0.00	0.00	0.00	18.54	0.00	
	0.00	0.25	0.00	6.67	0.00	0.00	0.00	0.30	0.00	
Ricefield, irrigated	85.31	22.78	37.56	5.68	0.22	0.00	0.00	29.41	43.29	224.25
	11.49	3.07	5.06	0.76	0.03	0.00	0.00	3.96	5.83	30.20
	38.04	10.16	16.75	2.53	0.10	0.00	0.00	13.12	19.30	
	39.08	14.02	50.92	26.41	11.45	0.00	0.00	21.22	35.17	
Grassland (70-90% dominant)	0.00	0.00	0.00	0.39	0.00	1.20	0.00	0.00	0.00	1.58
	0.00	0.00	0.00	0.05	0.00	0.16	0.00	0.00	0.00	0.21
	0.00	0.00	0.00	24.53	0.00	75.47	0.00	0.00	0.00	
	0.00	0.00	0.00	1.81	0.00	100.00	0.00	0.00	0.00	
Shrubs	43.26	109.11	14.22	5.86	1.73	0.00	0.00	81.80	28.98	284.96
	5.83	14.69	1.92	0.79	0.23	0.00	0.00	11.02	3.90	38.37
	15.18	38.29	4.99	2.05	0.61	0.00	0.00	28.71	10.17	
	19.82	67.13	19.28	27.24	88.55	0.00	0.00	59.01	23.54	
Coconut	0.00	9.07	4.47	6.41	0.00	0.00	0.00	8.14	3.50	31.58
	0.00	1.22	0.60	0.86	0.00	0.00	0.00	1.10	0.47	4.25
	0.00	28.71	14.14	20.29	0.00	0.00	0.00	25.78	11.07	
	0.00	5.58	6.06	29.81	0.00	0.00	0.00	5.87	2.84	
Built-up Areas	1.12	0.67	0.55	0.00	0.00	0.00	0.00	1.12	1.30	4.77
	0.15	0.09	0.07	0.00	0.00	0.00	0.00	0.15	0.18	0.64
	23.51	14.11	11.60	0.00	0.00	0.00	0.00	23.51	27.27	
	0.51	0.41	0.75	0.00	0.00	0.00	0.00	0.81	1.06	
Sugar cane	4.35	1.66	4.50	0.00	0.00	0.00	0.19	0.00	0.00	10.70
	0.59	0.22	0.61	0.00	0.00	0.00	0.03	0.00	0.00	1.44
	40.64	15.50	42.04	0.00	0.00	0.00	1.82	0.00	0.00	
	1.99	1.02	6.10	0.00	0.00	0.00	11.50	0.00	0.00	

Land Use	Bani	Bolinao	Anda	Santiago	Siapar Island	Hundred Islands	Cabalitian Island	Agno	Burgos	Total
Grassland (<70% dominant)	56.39	13.58	6.20	1.05	0.00	0.00	0.00	14.31	43.61	135.13
	7.59	1.83	0.83	0.14	0.00	0.00	0.00	1.93	5.87	18.20
	41.73	10.05	4.59	0.77	0.00	0.00	0.00	10.59	32.27	
	25.83	8.35	8.41	4.86	0.00	0.00	0.00	10.32	35.42	
Corn (>70% dominant)	0.00	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.60
	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08
	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	0.00	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Fishponds	22.02	0.54	5.02	0.69	0.00	0.00	0.00	0.67	0.00	28.94
	2.97	0.07	0.68	0.09	0.00	0.00	0.00	0.09	0.00	3.90
	76.10	1.86	17.35	2.37	0.00	0.00	0.00	2.32	0.00	
	10.09	0.33	6.81	3.20	0.00	0.00	0.00	0.48	0.00	
Saltbeds	0.00	0.00	1.24	0.00	0.00	0.00	0.00	0.00	0.00	1.24
	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.17
	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	1.68	0.00	0.00	0.00	0.00	0.00	0.00	
Ipil-ipil	0.70	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.32
	0.09	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18
	53.41	46.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	0.32	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Riverwash	0.00	0.00	0.00	0.00	0.00	0.00	1.49	0.48	0.00	1.97
	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.06	0.00	0.27
	0.00	0.00	0.00	0.00	0.00	0.00	75.76	24.24	0.00	
	0.00	0.00	0.00	0.00	0.00	0.00	88.50	0.34	0.00	
Maguey	0.00	3.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.51
	0.00	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47
	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	0.00	2.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Freshwater swamps	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.52
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.07
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42	
Kaingin	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.46
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.06
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	
Total	218.28	162.53	73.75	21.50	1.96	1.20	1.69	138.63	123.09	742.61
	29.39	21.89	9.93	2.89	0.26	0.16	0.23	18.67	16.58	

Area cross tabulation of the 1990 land use map for the municipalities of Pangasinan (Part III).

Area (km sq.)
Total %
Row %
Col %

Land Use	Mabini	Dasol	Infanta	Bugallon	Aguilar	Mangatarem
Forest	0.00	0.00	0.00	0.00	0.00	14.36
	0.00	0.00	0.00	0.00	0.00	0.95
	0.00	0.00	0.00	0.00	0.00	100.00
	0.00	0.00	0.00	0.00	0.00	5.01
Forest with	25.17	0.76	65.98	11.01	14.24	41.26
Associate landuses	1.66	0.05	4.36	0.73	0.94	2.73
	15.89	0.48	41.65	6.95	8.99	26.04
	11.10	0.45	28.22	7.08	9.85	14.40
Grassland (>90%	1.90	0.70	0.00	0.00	0.00	4.54
dominant)	0.13	0.05	0.00	0.00	0.00	0.30
	26.57	9.83	0.00	0.00	0.00	63.60
	0.84	0.41	0.00	0.00	0.00	1.58
Mangrove/nipa	0.00	0.00	0.00	5.72	0.00	0.00
	0.00	0.00	0.00	0.38	0.00	0.00
	0.00	0.00	0.00	100.00	0.00	0.00
	0.00	0.00	0.00	3.68	0.00	0.00
Ricefield, irrigated	17.33	30.55	18.54	48.44	41.78	119.80
	1.15	2.02	1.23	3.20	2.76	7.92
	3.70	6.51	3.95	10.33	8.91	25.55
	7.64	17.93	7.93	31.14	28.90	41.80
Shrubs	46.40	34.21	27.13	0.00	0.00	0.00
	3.07	2.26	1.79	0.00	0.00	0.00
	43.07	31.75	25.18	0.00	0.00	0.00
	20.46	20.08	11.60	0.00	0.00	0.00
Coconut	2.67	1.30	0.00	1.54	0.00	3.26
	0.18	0.09	0.00	0.10	0.00	0.22
	7.70	3.74	0.00	4.43	0.00	9.38
	1.18	0.76	0.00	0.99	0.00	1.14
Built-up Areas	0.46	0.99	0.51	5.57	5.59	11.68
	0.03	0.07	0.03	0.37	0.37	0.77
	0.79	1.69	0.87	9.54	9.57	20.00
	0.20	0.58	0.22	3.58	3.86	4.08

Land Use	Mabini	Dasol	Infanta	Bugallon	Aguilar	Mangatarem
Sugar cane	0.00	0.06	0.00	1.84	0.00	0.00
	0.00	0.00	0.00	0.12	0.00	0.00
	0.00	0.48	0.00	14.63	0.00	0.00
	0.00	0.04	0.00	1.18	0.00	0.00
Grassland (<70%	132.89	94.54	118.43	80.80	82.32	86.79
dominant)	8.79	6.25	7.83	5.34	5.44	5.74
	21.38	15.21	19.06	13.00	13.25	13.97
	58.59	55.48	50.65	51.94	56.94	30.28
Corn (>70%	0.00	0.00	0.00	0.00	0.00	0.00
dominant)	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
Fishponds	0.00	0.79	3.23	0.63	0.00	0.00
	0.00	0.05	0.21	0.04	0.00	0.00
	0.00	17.04	69.45	13.50	0.00	0.00
	0.00	0.46	1.38	0.40	0.00	0.00
Saltbeds	0.00	6.50	0.00	0.00	0.00	0.00
	0.00	0.43	0.00	0.00	0.00	0.00
	0.00	100.00	0.00	0.00	0.00	0.00
	0.00	3.81	0.00	0.00	0.00	0.00
Riverwash	0.00	0.00	0.00	0.00	0.66	1.76
	0.00	0.00	0.00	0.00	0.04	0.12
	0.00	0.00	0.00	0.00	18.49	49.58
	0.00	0.00	0.00	0.00	0.45	0.62
Freshwater swamps	0.00	0.00	0.00	0.00	0.00	3.15
	0.00	0.00	0.00	0.00	0.00	0.21
	0.00	0.00	0.00	0.00	0.00	43.96
	0.00	0.00	0.00	0.00	0.00	1.10
Total	226.82	170.40	233.81	155.55	144.59	286.61
	15.00	11.27	15.46	10.29	9.56	18.95

Land Use	Urbiztondo	Basista	Malasiqui	Sta. Barbara	Mapandan	Total
Forest	0.00	0.00	0.00	0.00	0.00	14.36
	0.00	0.00	0.00	0.00	0.00	0.95
	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	
Forest with Associate landuses	0.00	0.00	0.00	0.00	0.00	158.42
	0.00	0.00	0.00	0.00	0.00	10.48
	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	
Grassland (>90% dominant)	0.00	0.00	0.00	0.00	0.00	7.14
	0.00	0.00	0.00	0.00	0.00	0.47
	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	
Mangrove/nipa	0.00	0.00	0.00	0.00	0.00	5.72
	0.00	0.00	0.00	0.00	0.00	0.38
	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	
Ricefield, irrigated	38.59	18.91	71.49	53.46	10.04	468.94
	2.55	1.25	4.73	3.54	0.66	31.01
	8.23	4.03	15.25	11.40	2.14	
	71.51	63.27	59.97	77.03	45.75	
Shrubs	0.00	0.00	0.00	0.00	0.00	107.73
	0.00	0.00	0.00	0.00	0.00	7.12
	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	
Coconut	8.14	7.44	9.41	0.97	0.00	34.73
	0.54	0.49	0.62	0.06	0.00	2.30
	23.44	21.42	27.10	2.80	0.00	
	15.09	24.89	7.89	1.40	0.00	
Built-up Areas	3.27	3.48	10.96	11.52	4.38	58.41
	0.22	0.23	0.73	0.76	0.29	3.86
	5.60	5.96	18.77	19.72	7.49	
	6.06	11.64	9.20	16.59	19.95	
Sugar cane	0.00	0.00	0.00	3.14	7.53	12.56
	0.00	0.00	0.00	0.21	0.50	0.83
	0.00	0.00	0.00	24.97	59.93	
	0.00	0.00	0.00	4.52	34.31	
Grassland (<70% dominant)	0.00	0.00	25.35	0.31	0.00	621.45
	0.00	0.00	1.68	0.02	0.00	41.10
	0.00	0.00	4.08	0.05	0.00	
	0.00	0.00	21.26	0.45	0.00	

Land Use	Urbiztondo	Basista	Malasiqui	Sta. Barbara	Mapandan	Total
Corn (>70% dominant)	0.00	0.00	0.87	0.00	0.00	0.87
	0.00	0.00	0.06	0.00	0.00	0.06
	0.00	0.00	100.00	0.00	0.00	
	0.00	0.00	0.73	0.00	0.00	
Fishponds	0.00	0.00	0.00	0.00	0.00	4.65
	0.00	0.00	0.00	0.00	0.00	0.31
	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	
Saltbeds	0.00	0.00	0.00	0.00	0.00	6.50
	0.00	0.00	0.00	0.00	0.00	0.43
	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	
Riverwash	0.00	0.00	1.14	0.00	0.00	3.56
	0.00	0.00	0.08	0.00	0.00	0.24
	0.00	0.00	31.93	0.00	0.00	
	0.00	0.00	0.95	0.00	0.00	
Freshwater swamps	3.96	0.06	0.00	0.00	0.00	7.17
	0.26	0.00	0.00	0.00	0.00	0.47
	55.21	0.83	0.00	0.00	0.00	
	7.34	0.20	0.00	0.00	0.00	
Total	53.96	29.89	119.22	69.40	21.94	1,512.20
	3.57	1.98	7.88	4.59	1.45	

Area cross tabulation of the 1990 land use map for the municipalities of Pangasinan (Part IV).

Land Use	San Jacinto	Manaoag	Laoac	Pozorrubio	Sison	Binalonan
Forest	0.00	0.00	0.00	0.00	21.21	0.00
	0.00	0.00	0.00	0.00	2.24	0.00
	0.00	0.00	0.00	0.00	28.39	0.00
	0.00	0.00	0.00	0.00	18.94	0.00
Grassland (>90% dominant)	0.11	0.00	0.00	0.21	21.97	2.97
	0.01	0.00	0.00	0.02	2.32	0.31
	0.09	0.00	0.00	0.19	19.83	2.68
	0.34	0.00	0.00	0.26	19.62	4.57
Ricefield, irrigated	13.86	25.62	21.63	52.21	35.36	37.87
	1.46	2.71	2.29	5.52	3.74	4.00
	3.05	5.64	4.76	11.49	7.78	8.33
	45.71	55.81	69.25	65.56	31.56	58.26
Grassland (70-90% dominant)	0.00	0.00	0.00	0.00	1.27	0.00
	0.00	0.00	0.00	0.00	0.13	0.00
	0.00	0.00	0.00	0.00	1.93	0.00
	0.00	0.00	0.00	0.00	1.13	0.00
Shrubs	0.00	0.00	0.00	0.00	15.98	0.00
	0.00	0.00	0.00	0.00	1.69	0.00
	0.00	0.00	0.00	0.00	61.04	0.00
	0.00	0.00	0.00	0.00	14.27	0.00
Built-up Areas	5.71	8.74	3.87	8.07	1.72	6.81
	0.60	0.92	0.41	0.85	0.18	0.72
	7.73	11.84	5.24	10.93	2.33	9.23
	18.82	19.04	12.39	10.13	1.53	10.48
Coffee, citrus, lanzones	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
Cassava, potatoes, black pepper	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00

Land Use	San Jacinto	Manaoag	Laoac	Pozorrubio	Sison	Binalonan
Sugar cane	1.90	2.33	3.08	3.14	0.00	10.65
	0.20	0.25	0.33	0.33	0.00	1.13
	8.99	11.05	14.59	14.87	0.00	50.50
	6.26	5.08	9.85	3.94	0.00	16.39
Grassland (<70%	7.38	9.22	0.00	14.10	9.84	0.00
dominant)	0.78	0.97	0.00	1.49	1.04	0.00
	16.06	20.06	0.00	30.69	21.42	0.00
	24.33	20.08	0.00	17.71	8.79	0.00
Corn (>70%	0.00	0.00	1.43	0.00	0.00	0.00
dominant)	0.00	0.00	0.15	0.00	0.00	0.00
	0.00	0.00	36.92	0.00	0.00	0.00
	0.00	0.00	4.59	0.00	0.00	0.00
Riverwash	1.37	0.00	1.23	1.91	4.66	4.24
	0.15	0.00	0.13	0.20	0.49	0.45
	2.19	0.00	1.95	3.05	7.43	6.77
	4.53	0.00	3.92	2.40	4.16	6.53
Mango	0.00	0.00	0.00	0.00	0.00	2.45
	0.00	0.00	0.00	0.00	0.00	0.26
	0.00	0.00	0.00	0.00	0.00	100.00
	0.00	0.00	0.00	0.00	0.00	3.77
Total	30.33	45.91	31.24	79.64	112.02	65.00
	3.20	4.85	3.30	8.42	11.84	6.87

Land Use	Urdaneta	Asingan	San Manu	San Nicolas	Tayug	Total
Forest	0.00	0.00	13.82	39.69	0.00	74.72
	0.00	0.00	1.46	4.19	0.00	7.90
	0.00	0.00	18.49	53.12	0.00	
	0.00	0.00	11.92	18.05	0.00	
Grassland (>90% dominant)	0.00	0.00	35.25	50.28	0.00	110.80
	0.00	0.00	3.73	5.31	0.00	11.71
	0.00	0.00	31.82	45.38	0.00	
	0.00	0.00	30.41	22.86	0.00	
Ricefield, irrigated	104.45	52.72	39.74	38.69	32.30	454.44
	11.04	5.57	4.20	4.09	3.41	48.02
	22.98	11.60	8.74	8.51	7.11	
	81.41	70.66	34.27	17.59	74.35	
Grassland (70-90% dominant)	0.00	0.00	1.39	63.00	0.00	65.65
	0.00	0.00	0.15	6.66	0.00	6.94
	0.00	0.00	2.12	95.95	0.00	
	0.00	0.00	1.20	28.64	0.00	
Shrubs	0.42	0.00	0.00	9.79	0.00	26.19
	0.04	0.00	0.00	1.03	0.00	2.77
	1.60	0.00	0.00	37.36	0.00	
	0.33	0.00	0.00	4.45	0.00	
Built-up Areas	19.64	7.31	2.51	4.44	4.99	73.80
	2.08	0.77	0.27	0.47	0.53	7.80
	26.62	9.90	3.40	6.01	6.76	
	15.31	9.79	2.16	2.02	11.49	
Coffee, citrus, lanzones	0.00	1.15	1.14	0.00	0.00	2.29
	0.00	0.12	0.12	0.00	0.00	0.24
	0.00	50.33	49.67	0.00	0.00	
	0.00	1.54	0.98	0.00	0.00	
Cassava, potatoes, black pepper	0.49	0.00	1.48	0.39	0.00	2.36
	0.05	0.00	0.16	0.04	0.00	0.25
	20.89	0.00	62.66	16.46	0.00	
	0.38	0.00	1.28	0.18	0.00	
Sugar cane	0.00	0.00	0.00	0.00	0.00	21.09
	0.00	0.00	0.00	0.00	0.00	2.23
	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	
Grassland (<70% dominant)	3.11	0.00	2.30	0.00	0.00	45.95
	0.33	0.00	0.24	0.00	0.00	4.86
	6.76	0.00	5.01	0.00	0.00	
	2.42	0.00	1.98	0.00	0.00	

Land Use	Urdaneta	Asingan	San Manu	San Nicolas	Tayug	Total
Corn (>70% dominant)	0.02	2.44	0.00	0.00	0.00	3.88
	0.00	0.26	0.00	0.00	0.00	0.41
	0.38	62.69	0.00	0.00	0.00	
	0.01	3.26	0.00	0.00	0.00	
Riverwash	0.18	11.00	18.31	13.65	6.16	62.71
	0.02	1.16	1.94	1.44	0.65	6.63
	0.29	17.53	29.20	21.77	9.81	
	0.14	14.74	15.80	6.21	14.17	
Mango	0.00	0.00	0.00	0.00	0.00	2.45
	0.00	0.00	0.00	0.00	0.00	0.26
	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	
Total	128.31	74.60	115.94	219.92	43.44	946.33
	13.56	7.88	12.25	23.24	4.59	

Area cross tabulation of the 1990 land use map for the municipalities of Pangasinan (Part V).

Area (km sq.)
Total %
Row %
Col %

Land Use	Natividad	San Quintin	Sta. Maria	Umingan	Balungao	Rosales
Forest with associated land uses	23.62	49.52	0.00	21.62	0.00	0.00
	2.50	5.23	0.00	2.28	0.00	0.00
	24.93	52.26	0.00	22.81	0.00	0.00
	27.54	43.37	0.00	8.39	0.00	0.00
Grassland (>90% dominant)	9.67	15.95	0.00	8.49	1.18	0.48
	1.02	1.69	0.00	0.90	0.12	0.05
	27.03	44.61	0.00	23.73	3.30	1.34
	11.27	13.97	0.00	3.29	1.54	0.73
Mangroves/nipa	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
Ricefield, irrigated	18.08	33.66	34.22	151.74	44.04	47.77
	1.91	3.56	3.62	16.03	4.65	5.05
	3.29	6.12	6.23	27.61	8.01	8.69
	21.08	29.47	70.25	58.87	57.47	72.53
Shrubs	23.17	5.78	0.00	4.03	0.00	0.00
	2.45	0.61	0.00	0.43	0.00	0.00
	70.24	17.53	0.00	12.23	0.00	0.00
	27.02	5.06	0.00	1.56	0.00	0.00
Coconut	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
Built-up Areas	3.99	6.17	5.45	6.29	5.36	4.62
	0.42	0.65	0.58	0.66	0.57	0.49
	8.01	12.39	10.95	12.64	10.77	9.27
	4.65	5.40	11.19	2.44	7.00	7.01
Cassava, potatoes, black pepper	3.29	0.02	0.00	0.00	0.00	0.00
	0.35	0.00	0.00	0.00	0.00	0.00
	33.08	0.15	0.00	0.00	0.00	0.00
	3.83	0.01	0.00	0.00	0.00	0.00

Land Use	Natividad	San Quintin	Sta. Maria	Umingan	Balungao	Rosales
Sugar cane	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
Grassland (<70%	0.28	1.00	0.00	60.53	25.08	9.50
dominant)	0.03	0.11	0.00	6.40	2.65	1.00
	0.25	0.87	0.00	52.51	21.76	8.24
	0.33	0.88	0.00	23.48	32.73	14.43
Corn (>70%	0.00	0.00	0.48	0.00	0.00	0.69
dominant)	0.00	0.00	0.05	0.00	0.00	0.07
	0.00	0.00	5.28	0.00	0.00	7.59
	0.00	0.00	0.98	0.00	0.00	1.04
Riverwash	3.56	2.09	8.56	5.05	0.97	2.81
	0.38	0.22	0.90	0.53	0.10	0.30
	11.67	6.86	28.09	16.57	3.19	9.22
	4.15	1.83	17.57	1.96	1.27	4.26
Mango	0.11	0.00	0.00	0.00	0.00	0.00
	0.01	0.00	0.00	0.00	0.00	0.00
	100.00	0.00	0.00	0.00	0.00	0.00
	0.12	0.00	0.00	0.00	0.00	0.00
Freshwater swamps	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
Total	85.75	114.19	48.71	257.75	76.63	65.86
	9.06	12.06	5.15	27.23	8.10	6.96

Land Use	Villasis	Sto. Toma	Alcala	Bautista	Bayambang	Total
Forest with associated land uses	0.00	0.00	0.00	0.00	0.00	94.75
	0.00	0.00	0.00	0.00	0.00	10.01
	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	
Grassland (>90% dominant)	0.00	0.00	0.00	0.00	0.00	35.76
	0.00	0.00	0.00	0.00	0.00	3.78
	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	
Mangroves/nipa	0.00	0.00	0.00	0.00	2.97	2.97
	0.00	0.00	0.00	0.00	0.31	0.31
	0.00	0.00	0.00	0.00	100.00	
	0.00	0.00	0.00	0.00	3.19	
Ricefield, irrigated	49.89	7.11	33.28	58.71	71.15	549.65
	5.27	0.75	3.52	6.20	7.52	58.07
	9.08	1.29	6.06	10.68	12.94	
	63.50	55.61	74.02	86.15	76.43	
Shrubs	0.00	0.00	0.00	0.00	0.00	32.98
	0.00	0.00	0.00	0.00	0.00	3.48
	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	
Coconut	0.00	0.00	0.08	2.44	4.72	7.23
	0.00	0.00	0.01	0.26	0.50	0.76
	0.00	0.00	1.03	33.68	65.29	
	0.00	0.00	0.17	3.57	5.07	
Built-up Areas	5.38	1.02	4.54	1.37	5.59	49.77
	0.57	0.11	0.48	0.15	0.59	5.26
	10.80	2.04	9.12	2.76	11.22	
	6.84	7.94	10.10	2.02	6.00	
Cassava, potatoes, black pepper	4.96	0.00	0.00	1.30	0.37	9.93
	0.52	0.00	0.00	0.14	0.04	1.05
	49.92	0.00	0.00	13.08	3.76	
	6.31	0.00	0.00	1.91	0.40	
Sugar cane	0.00	1.91	0.75	0.00	0.00	2.66
	0.00	0.20	0.08	0.00	0.00	0.28
	0.00	71.91	28.09	0.00	0.00	
	0.00	14.95	1.66	0.00	0.00	
Grassland (<70% dominant)	13.67	0.00	0.00	0.00	5.20	115.26
	1.44	0.00	0.00	0.00	0.55	12.18
	11.86	0.00	0.00	0.00	4.51	
	17.40	0.00	0.00	0.00	5.58	

Land Use	Villasis	Sto. Toma	Alcala	Bautista	Bayambang	Total
Corn (>70% dominant)	2.50	1.73	3.66	0.00	0.00	9.05
	0.26	0.18	0.39	0.00	0.00	0.96
	27.56	19.14	40.43	0.00	0.00	
	3.17	13.55	8.14	0.00	0.00	
Riverwash	2.18	1.02	2.23	0.08	1.94	30.47
	0.23	0.11	0.24	0.01	0.21	3.22
	7.16	3.33	7.30	0.25	6.37	
	2.78	7.94	4.95	0.11	2.09	
Mango	0.00	0.00	0.00	0.00	0.00	0.11
	0.00	0.00	0.00	0.00	0.00	0.01
	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	
Freshwater swamps	0.00	0.00	0.43	4.26	1.15	5.84
	0.00	0.00	0.05	0.45	0.12	0.62
	0.00	0.00	7.42	72.89	19.69	
	0.00	0.00	0.96	6.25	1.24	
Total	78.58	12.79	44.96	68.15	93.10	946.46
	8.30	1.35	4.75	7.20	9.84	

Area cross tabulation of the 1990 land use map for the municipalities of Benguet.

Area (km sq.)
Total %
Row %
Col %

Land Use	Bakun	Mankayan	Buguias	Kibungan	Kabayan
Forest with	90.69	106.55	48.71	73.24	104.82
Associated Landuses	3.33	3.91	1.79	2.69	3.85
	7.76	9.11	4.17	6.26	8.97
	55.47	47.41	40.08	45.39	66.22
Ricefield, irrigated	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
Grassland (90-70%	61.22	63.94	6.36	41.10	37.96
dominant)	2.25	2.35	0.23	1.51	1.39
	7.25	7.57	0.75	4.87	4.49
	37.45	28.45	5.24	25.47	23.98
Shrubs	0.00	6.81	1.33	23.38	0.00
	0.00	0.25	0.05	0.86	0.00
	0.00	2.89	0.56	9.91	0.00
	0.00	3.03	1.09	14.49	0.00
Built-up Areas	0.00	2.08	0.00	0.00	0.00
	0.00	0.08	0.00	0.00	0.00
	0.00	38.72	0.00	0.00	0.00
	0.00	0.92	0.00	0.00	0.00
Grassland (<70%	8.32	0.00	0.00	0.10	0.00
dominant)	0.31	0.00	0.00	0.00	0.00
	4.21	0.00	0.00	0.05	0.00
	5.09	0.00	0.00	0.06	0.00
Rice terraces	3.26	9.59	0.00	1.85	3.82
	0.12	0.35	0.00	0.07	0.14
	3.16	9.31	0.00	1.80	3.71
	1.99	4.27	0.00	1.15	2.42

Land Use	Bakun	Mankayan	Bugulas	Kibungan	Kabayan
Vegetable terraces	0.00	35.78	65.13	21.69	10.50
	0.00	1.31	2.39	0.80	0.39
	0.00	23.59	42.94	14.30	6.92
	0.00	15.92	53.59	13.44	6.63
Mines	0.00	0.00	0.00	0.00	1.18
	0.00	0.00	0.00	0.00	0.04
	0.00	0.00	0.00	0.00	13.19
	0.00	0.00	0.00	0.00	0.75
Filling Ponds	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
Reservoirs	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
Total	163.48	224.75	121.54	161.36	158.29
	6.00	8.25	4.46	5.92	5.81

Land Use	Atok	Kapangan	Tublay	Sablan	La Trinidad
Forest with Associated Landuses	62.88	6.78	15.74	9.69	11.17
	2.31	0.25	0.58	0.36	0.41
	5.38	0.58	1.35	0.83	0.96
	45.28	4.65	16.46	9.17	14.28
Ricefield, irrigated	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
Grassland (90-70% dominant)	35.21	42.08	9.84	34.66	11.37
	1.29	1.54	0.36	1.27	0.42
	4.17	4.98	1.17	4.10	1.35
	25.36	28.87	10.29	32.80	14.53
Shrubs	8.14	36.46	24.86	28.74	1.76
	0.30	1.34	0.91	1.06	0.06
	3.45	15.46	10.54	12.18	0.75
	5.86	25.01	25.99	27.20	2.25
Built-up Areas	0.00	0.00	0.00	0.00	3.27
	0.00	0.00	0.00	0.00	0.12
	0.00	0.00	0.00	0.00	61.00
	0.00	0.00	0.00	0.00	4.18
Grassland (<70% dominant)	16.04	44.71	17.93	30.73	41.02
	0.59	1.64	0.66	1.13	1.51
	8.12	22.62	9.07	15.55	20.76
	11.55	30.67	18.74	29.08	52.41
Rice terraces	8.62	15.22	24.38	1.85	0.66
	0.32	0.56	0.89	0.07	0.02
	8.37	14.78	23.67	1.80	0.64
	6.21	10.44	25.49	1.75	0.84
Vegetable terraces	5.65	0.52	2.88	0.00	6.29
	0.21	0.02	0.11	0.00	0.23
	3.72	0.34	1.90	0.00	4.15
	4.07	0.36	3.01	0.00	8.04
Mines	1.87	0.00	0.00	0.00	2.72
	0.07	0.00	0.00	0.00	0.10
	20.87	0.00	0.00	0.00	30.38
	1.34	0.00	0.00	0.00	3.47

Land Use	Atok	Kapangan	Tublay	Sablan	La Trinidad
Filling Ponds	0.45	0.00	0.00	0.00	0.00
	0.02	0.00	0.00	0.00	0.00
	49.18	0.00	0.00	0.00	0.00
	0.32	0.00	0.00	0.00	0.00
Reservoirs	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
Total	138.85	145.78	95.63	105.67	78.26
	5.10	5.35	3.51	3.88	2.87

Land Use	Tuba	Baguio	Itogon	Bokod	Total
Forest with	121.87	22.15	266.71	228.17	1,169.19
Associated Landuses	4.47	0.81	9.79	8.38	42.92
	10.42	1.89	22.81	19.51	
	34.77	38.76	48.15	61.83	
Ricefield, irrigated	0.27	0.00	0.00	0.00	0.27
	0.01	0.00	0.00	0.00	0.01
	100.00	0.00	0.00	0.00	
	0.08	0.00	0.00	0.00	
Grassland (90-70%	135.04	23.26	234.35	108.32	844.70
dominant)	4.96	0.85	8.60	3.98	31.01
	15.99	2.75	27.74	12.82	
	38.53	40.70	42.31	29.35	
Shrubs	73.54	6.09	23.99	0.82	235.94
	2.70	0.22	0.88	0.03	8.66
	31.17	2.58	10.17	0.35	
	20.98	10.66	4.33	0.22	
Built-up Areas	0.01	0.00	0.00	0.00	5.36
	0.00	0.00	0.00	0.00	0.20
	0.28	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	
Grassland (<70%	13.04	2.54	17.30	5.89	197.62
dominant)	0.48	0.09	0.63	0.22	7.25
	6.60	1.29	8.75	2.98	
	3.72	4.44	3.12	1.59	
Rice terraces	5.42	1.52	7.45	19.36	103.01
	0.20	0.06	0.27	0.71	3.78
	5.26	1.48	7.24	18.79	
	1.55	2.67	1.35	5.25	
Vegetable terraces	0.39	1.58	0.63	0.63	151.67
	0.01	0.06	0.02	0.02	5.57
	0.26	1.04	0.41	0.41	
	0.11	2.77	0.11	0.17	
Mines	0.91	0.00	0.00	2.27	8.95
	0.03	0.00	0.00	0.08	0.33
	10.18	0.00	0.00	25.38	
	0.26	0.00	0.00	0.62	

Land Use	Tuba	Baguio	Itogon	Bokod	Total
Filling Ponds	0.00	0.00	0.46	0.00	0.91
	0.00	0.00	0.02	0.00	0.03
	0.00	0.00	50.82	0.00	
	0.00	0.00	0.08	0.00	
Reservoirs	0.00	0.00	3.03	3.60	6.63
	0.00	0.00	0.11	0.13	0.24
	0.00	0.00	45.72	54.28	
	0.00	0.00	0.55	0.98	
Total	350.50	57.15	553.93	369.05	2,724.25
	12.87	2.10	20.33	13.55	

Area cross tabulation of the 1990 land use map for the municipalities of Tarlac.

Area (km sq.)
Total %
Row %
Col %

Land Use	Bamban	Concepcion	O'Donnel	Tarlac	La Paz	Victoria
Forest	44.76	0.00	97.79	239.46	0.00	0.00
	1.46	0.00	3.18	7.80	0.00	0.00
	7.95	0.00	17.37	42.55	0.00	0.00
	30.84	0.00	19.01	31.62	0.00	0.00
Forest with	0.00	0.00	0.00	0.00	0.00	0.00
associated land uses	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
Grassland (>90%	9.50	0.00	28.40	60.14	0.00	0.00
dominant)	0.31	0.00	0.92	1.96	0.00	0.00
	3.30	0.00	9.86	20.88	0.00	0.00
	6.55	0.00	5.52	7.94	0.00	0.00
Mangroves/nipa	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
Ricefield, irrigated	11.53	155.58	126.44	191.54	110.95	80.41
	0.38	5.07	4.12	6.24	3.61	2.62
	0.97	13.06	10.61	16.08	9.31	6.75
	7.95	72.59	24.58	25.29	90.10	66.17
Grassland (70-90%	0.00	0.00	25.47	95.13	0.00	0.00
dominant)	0.00	0.00	0.83	3.10	0.00	0.00
	0.00	0.00	19.68	73.52	0.00	0.00
	0.00	0.00	4.95	12.56	0.00	0.00
Shrubs	0.00	0.00	0.00	53.48	0.00	0.00
	0.00	0.00	0.00	1.74	0.00	0.00
	0.00	0.00	0.00	89.66	0.00	0.00
	0.00	0.00	0.00	7.06	0.00	0.00
Coconut	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00

Land Use	Bamban	Concepcion	O'Donnel	Tarlac	La Paz	Victoria
Built-up Areas	3.60	5.00	7.35	14.95	2.27	4.29
	0.12	0.16	0.24	0.49	0.07	0.14
	4.25	5.91	8.68	17.67	2.68	5.07
	2.48	2.33	1.43	1.97	1.84	3.53
Cassava, potatoes, black pepper	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
Sugar cane	5.60	47.37	15.80	37.41	9.92	36.82
	0.18	1.54	0.51	1.22	0.32	1.20
	2.00	16.90	5.64	13.35	3.54	13.14
	3.86	22.10	3.07	4.94	8.06	30.30
Grassland (<70% dominant)	65.59	0.00	198.47	31.82	0.00	0.00
	2.14	0.00	6.46	1.04	0.00	0.00
	22.06	0.00	66.76	10.70	0.00	0.00
	45.19	0.00	38.58	4.20	0.00	0.00
Riverwash	4.56	6.36	14.67	33.36	0.00	0.00
	0.15	0.21	0.48	1.09	0.00	0.00
	5.21	7.28	16.79	38.17	0.00	0.00
	3.14	2.97	2.85	4.40	0.00	0.00
Freshwater swamps	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
Total	145.14	214.32	514.38	757.28	123.14	121.52
	4.73	6.98	16.75	24.66	4.01	3.96

Land Use	Pura	Gerona	Sta. Ignasi	Mayantoc	Camiling	Paniqui
Forest	0.00	0.00	0.00	173.15	0.00	0.00
	0.00	0.00	0.00	5.64	0.00	0.00
	0.00	0.00	0.00	30.76	0.00	0.00
	0.00	0.00	0.00	49.59	0.00	0.00
Forest with associated land uses	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
Grassland (>90% dominant)	0.00	6.36	33.04	106.88	22.80	0.00
	0.00	0.21	1.08	3.48	0.74	0.00
	0.00	2.21	11.47	37.11	7.91	0.00
	0.00	5.34	28.07	30.61	12.42	0.00
Mangroves/nipa	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
Ricefield, irrigated	6.69	47.28	77.72	58.36	128.66	18.36
	0.22	1.54	2.53	1.90	4.19	0.60
	0.56	3.97	6.53	4.90	10.80	1.54
	20.46	39.65	66.02	16.71	70.11	19.50
Grassland (70-90% dominant)	0.00	8.80	0.00	0.00	0.00	0.00
	0.00	0.29	0.00	0.00	0.00	0.00
	0.00	6.80	0.00	0.00	0.00	0.00
	0.00	7.38	0.00	0.00	0.00	0.00
Shrubs	0.00	0.00	3.09	0.00	3.08	0.00
	0.00	0.00	0.10	0.00	0.10	0.00
	0.00	0.00	5.18	0.00	5.16	0.00
	0.00	0.00	2.63	0.00	1.68	0.00
Coconut	0.00	0.00	0.00	0.00	0.61	0.00
	0.00	0.00	0.00	0.00	0.02	0.00
	0.00	0.00	0.00	0.00	100.00	0.00
	0.00	0.00	0.00	0.00	0.33	0.00
Built-up Areas	2.84	4.72	3.87	2.18	8.31	5.83
	0.09	0.15	0.13	0.07	0.27	0.19
	3.35	5.58	4.57	2.58	9.81	6.88
	8.68	3.96	3.29	0.62	4.53	6.19

Land Use	Pura	Gerona	Sta. Ignasi	Mayantoc	Camiling	Paniqui
Cassava, potatoes, black pepper	0.00	16.54	0.00	0.00	3.99	31.04
	0.00	0.54	0.00	0.00	0.13	1.01
	0.00	22.58	0.00	0.00	5.45	42.38
	0.00	13.87	0.00	0.00	2.17	32.97
Sugar cane	23.18	30.15	0.00	0.00	0.00	33.73
	0.76	0.98	0.00	0.00	0.00	1.10
	8.27	10.76	0.00	0.00	0.00	12.03
	70.87	25.28	0.00	0.00	0.00	35.83
Grassland (<70% dominant)	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
Riverwash	0.00	5.39	0.00	8.62	15.76	5.18
	0.00	0.18	0.00	0.28	0.51	0.17
	0.00	6.17	0.00	9.86	16.22	5.93
	0.00	4.52	0.00	2.47	8.58	5.51
Freshwater swamps	0.00	0.00	0.00	0.00	0.31	0.00
	0.00	0.00	0.00	0.00	0.01	0.00
	0.00	0.00	0.00	0.00	31.34	0.00
	0.00	0.00	0.00	0.00	0.17	0.00
Total	32.71	119.24	117.73	349.20	183.52	94.14
	1.07	3.88	3.83	11.37	5.98	3.07

Land Use	Ramos	Nampicuan	Moncada	San Man	San Clem	Total
Forest	0.00	0.00	0.00	0.00	7.68	562.83
	0.00	0.00	0.00	0.00	0.25	18.33
	0.00	0.00	0.00	0.00	1.36	
	0.00	0.00	0.00	0.00	10.79	
Forest with associated land uses	0.00	0.00	0.00	0.00	0.54	0.54
	0.00	0.00	0.00	0.00	0.02	0.02
	0.00	0.00	0.00	0.00	100.00	
	0.00	0.00	0.00	0.00	0.76	
Grassland (>90% dominant)	0.00	0.00	0.00	0.00	20.93	288.05
	0.00	0.00	0.00	0.00	0.68	9.38
	0.00	0.00	0.00	0.00	7.27	
	0.00	0.00	0.00	0.00	29.41	
Mangroves/nipa	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	
Ricefield, irrigated	7.56	20.36	67.40	45.38	36.93	1,191.16
	0.25	0.66	2.20	1.48	1.20	38.79
	0.63	1.71	5.66	3.81	3.10	
	23.87	80.27	56.19	90.74	51.89	
Grassland (70-90% dominant)	0.00	0.00	0.00	0.00	0.00	129.40
	0.00	0.00	0.00	0.00	0.00	4.21
	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	
Shrubs	0.00	0.00	0.00	0.00	0.00	59.65
	0.00	0.00	0.00	0.00	0.00	1.94
	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	
Coconut	0.00	0.00	0.00	0.00	0.00	0.61
	0.00	0.00	0.00	0.00	0.00	0.02
	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	
Built-up Areas	0.00	2.69	8.41	4.63	3.69	84.63
	0.00	0.09	0.27	0.15	0.12	2.76
	0.00	3.18	9.94	5.47	4.36	
	0.00	10.60	7.01	9.26	5.18	
Cassava, potatoes, black pepper	0.00	0.00	26.37	0.00	0.00	77.94
	0.00	0.00	0.85	0.00	0.00	2.54
	0.00	0.00	33.83	0.00	0.00	
	0.00	0.00	21.98	0.00	0.00	

Land Use	Ramos	Nampicuan	Moncada	San Man	San Clem	Total
Sugar cane	23.39	1.63	15.27	0.00	0.00	280.27
	0.76	0.05	0.50	0.00	0.00	9.13
	8.35	0.58	5.45	0.00	0.00	
	73.87	6.42	12.73	0.00	0.00	
Grassland (<70% dominant)	0.00	0.00	0.00	0.00	1.40	297.29
	0.00	0.00	0.00	0.00	0.05	9.68
	0.00	0.00	0.00	0.00	0.47	
	0.00	0.00	0.00	0.00	1.97	
Riverwash	0.72	0.69	1.82	0.00	0.00	97.13
	0.02	0.02	0.06	0.00	0.00	3.16
	0.82	0.79	2.09	0.00	0.00	
	2.26	2.71	1.52	0.00	0.00	
Freshwater swamps	0.00	0.00	0.69	0.00	0.00	1.00
	0.00	0.00	0.02	0.00	0.00	0.03
	0.00	0.00	68.66	0.00	0.00	
	0.00	0.00	0.57	0.00	0.00	
Total	31.67	25.37	119.95	50.01	71.17	3,070.49
	1.03	0.83	3.91	1.63	2.32	

Area cross tabulation of the 1990 land use map for the municipalities of La Union.

Area (km sq)
Total %
Row %
Col %

	Bangar	Luna	Balaoan	Bacnotan	San Juan
Forest with associated landuses	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
Grassland (>90% dominant)	0.00	0.00	0.00	1.25	0.66
	0.00	0.00	0.00	0.09	0.05
	0.00	0.00	0.00	1.33	0.70
	0.00	0.00	0.00	1.92	1.09
Ricefield, irrigated	18.09	20.24	23.72	25.10	25.02
	1.26	1.41	1.65	1.75	1.74
	5.84	6.53	7.65	8.10	8.07
	43.67	50.06	33.94	38.50	41.53
Grassland (70-90 dominant)	8.07	8.86	29.59	18.27	14.43
	0.56	0.62	2.06	1.27	1.00
	3.87	4.25	14.21	8.77	6.93
	19.47	21.91	42.34	28.02	23.95
Shrubs	0.00	1.57	8.08	15.79	12.89
	0.00	0.11	0.56	1.10	0.90
	0.00	0.42	2.17	4.24	3.46
	0.00	3.88	11.56	24.22	21.40
Coconut	1.90	0.00	0.00	0.00	0.00
	0.13	0.00	0.00	0.00	0.00
	38.60	0.00	0.00	0.00	0.00
	4.58	0.00	0.00	0.00	0.00
Built-up Areas	4.63	5.08	7.65	4.78	3.42
	0.32	0.35	0.53	0.33	0.24
	6.02	6.61	9.95	6.22	4.45
	11.18	12.56	10.94	7.33	5.68
Grassland (<70% dominant)	0.43	0.00	0.85	0.00	2.75
	0.03	0.00	0.06	0.00	0.19
	0.32	0.00	0.63	0.00	2.05
	1.05	0.00	1.22	0.00	4.56
Corn (>70% dominant)	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
Fishponds	0.52	1.18	0.00	0.00	0.00
	0.04	0.08	0.00	0.00	0.00
	3.34	7.54	0.00	0.00	0.00
	1.26	2.92	0.00	0.00	0.00

	Bangar	Luna	Balaoan	Bacnotan	San Juan
Bamboos	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
Ricefield, upland	0.00	0.00	0.00	0.00	0.10
	0.00	0.00	0.00	0.00	0.01
	0.00	0.00	0.00	0.00	1.45
	0.00	0.00	0.00	0.00	0.17
Beach sands	0.93	1.67	0.00	0.00	0.00
	0.06	0.12	0.00	0.00	0.00
	17.87	32.28	0.00	0.00	0.00
	2.24	4.14	0.00	0.00	0.00
Riverwash	6.86	0.00	0.00	0.00	0.97
	0.48	0.00	0.00	0.00	0.07
	35.17	0.00	0.00	0.00	4.98
	16.55	0.00	0.00	0.00	1.61
Rice terraces	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
Grapes	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
Mango	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
Vegetables, lowland	0.00	1.84	0.00	0.00	0.00
	0.00	0.13	0.00	0.00	0.00
	0.00	15.79	0.00	0.00	0.00
	0.00	4.54	0.00	0.00	0.00
Airport	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
Total	41.42	40.44	69.90	65.19	60.25
	2.88	2.82	4.87	4.54	4.19

	San Fernando	Bauang	Caba	Aringay	Agoo
Forest with associated landuses	0.00	0.00	0.00	14.89	0.00
	0.00	0.00	0.00	1.04	0.00
	0.00	0.00	0.00	8.95	0.00
	0.00	0.00	0.00	15.13	0.00
Grassland (>90% dominant)	3.35	0.46	0.00	2.57	3.03
	0.23	0.03	0.00	0.18	0.21
	3.56	0.49	0.00	2.73	3.22
	3.39	0.61	0.00	2.61	7.75
Ricefield, irrigated	19.88	18.54	10.23	18.31	17.24
	1.38	1.29	0.71	1.27	1.20
	6.42	5.98	3.30	5.91	5.56
	20.12	24.45	20.69	18.60	44.06
Grassland (70-90 dominant)	23.35	6.71	0.00	3.97	1.61
	1.63	0.47	0.00	0.28	0.11
	11.21	3.22	0.00	1.91	0.77
	23.63	8.85	0.00	4.04	4.12
Shrubs	28.85	19.42	13.22	23.93	10.74
	2.01	1.35	0.92	1.67	0.75
	7.75	5.22	3.55	6.43	2.88
	29.20	25.61	26.73	24.31	27.45
Coconut	0.00	1.54	0.00	1.48	0.00
	0.00	0.11	0.00	0.10	0.00
	0.00	31.31	0.00	30.09	0.00
	0.00	2.03	0.00	1.50	0.00
Built-up Areas	11.73	5.44	2.21	8.63	6.12
	0.82	0.38	0.15	0.60	0.43
	15.25	7.07	2.88	11.23	7.97
	11.87	7.17	4.47	8.77	15.65
Grassland (<70% dominant)	5.83	15.33	22.27	16.81	0.00
	0.41	1.07	1.55	1.17	0.00
	4.34	11.41	16.58	12.51	0.00
	5.90	20.21	45.03	17.07	0.00
Corn (>70% dominant)	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
Fishponds	2.54	1.31	0.00	6.08	0.27
	0.18	0.09	0.00	0.42	0.02
	16.22	8.40	0.00	38.84	1.72
	2.57	1.73	0.00	6.18	0.69

	San Fernando	Bauang	Caba	Aringay	Agoo
Bamboos	0.84	0.00	0.00	0.00	0.00
	0.06	0.00	0.00	0.00	0.00
	100.00	0.00	0.00	0.00	0.00
	0.85	0.00	0.00	0.00	0.00
Ricefield, upland	2.18	0.00	0.00	0.00	0.00
	0.15	0.00	0.00	0.00	0.00
	30.23	0.00	0.00	0.00	0.00
	2.21	0.00	0.00	0.00	0.00
Beach sands	0.00	0.99	0.60	0.42	0.10
	0.00	0.07	0.04	0.03	0.01
	0.00	19.02	11.53	8.07	2.02
	0.00	1.30	1.21	0.42	0.27
Riverwash	0.00	2.45	0.19	0.21	0.00
	0.00	0.17	0.01	0.01	0.00
	0.00	12.57	1.00	1.07	0.00
	0.00	3.23	0.39	0.21	0.00
Rice terraces	0.00	0.00	0.00	0.88	0.00
	0.00	0.00	0.00	0.06	0.00
	0.00	0.00	0.00	31.05	0.00
	0.00	0.00	0.00	0.90	0.00
Grapes	0.00	0.19	0.73	0.00	0.00
	0.00	0.01	0.05	0.00	0.00
	0.00	20.90	79.03	0.00	0.00
	0.00	0.26	1.48	0.00	0.00
Mango	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
Vegetables, lowland	0.01	3.45	0.00	0.25	0.00
	0.00	0.24	0.00	0.02	0.00
	0.13	29.65	0.00	2.18	0.00
	0.02	4.55	0.00	0.26	0.00
Airport	0.25	0.00	0.00	0.00	0.00
	0.02	0.00	0.00	0.00	0.00
	100.00	0.00	0.00	0.00	0.00
	0.26	0.00	0.00	0.00	0.00
Total	98.80	75.83	49.46	98.44	39.12
	6.88	5.28	3.44	6.85	2.72

	Sto. Tomas	Rosario	Pugo	Tubao	Naguilian
Forest with associated landuses	0.00	0.00	5.12	16.58	0.00
	0.00	0.00	0.36	1.15	0.00
	0.00	0.00	3.08	9.96	0.00
	0.00	0.00	11.76	29.17	0.00
Grassland (>90% dominant)	15.01	28.49	4.77	4.17	1.79
	1.05	1.98	0.33	0.29	0.12
	15.96	30.28	5.07	4.43	1.91
	24.27	41.14	10.94	7.33	1.89
Ricefield, irrigated	23.11	30.55	10.25	8.78	17.37
	1.61	2.13	0.71	0.61	1.21
	7.46	9.86	3.31	2.83	5.61
	37.36	44.12	23.52	15.45	18.29
Grassland (70-90 dominant)	0.00	0.96	2.87	2.51	17.10
	0.00	0.07	0.20	0.17	1.19
	0.00	0.46	1.38	1.21	8.21
	0.00	1.38	6.58	4.42	18.01
Shrubs	16.34	5.60	18.88	3.54	18.60
	1.14	0.39	1.31	0.25	1.29
	4.39	1.50	5.07	0.95	5.00
	26.42	8.09	43.33	6.23	19.58
Coconut	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
Built-up Areas	2.70	3.64	0.64	3.24	4.00
	0.19	0.25	0.04	0.23	0.28
	3.52	4.74	0.84	4.22	5.21
	4.37	5.26	1.47	5.70	4.22
Grassland (<70% dominant)	0.46	0.00	0.60	17.72	22.50
	0.03	0.00	0.04	1.23	1.57
	0.34	0.00	0.44	13.19	16.75
	0.75	0.00	1.37	31.17	23.69
Corn (>70% dominant)	0.00	0.00	0.00	0.00	2.96
	0.00	0.00	0.00	0.00	0.21
	0.00	0.00	0.00	0.00	100.00
	0.00	0.00	0.00	0.00	3.11
Fishponds	3.75	0.00	0.00	0.00	0.00
	0.26	0.00	0.00	0.00	0.00
	23.95	0.00	0.00	0.00	0.00
	6.06	0.00	0.00	0.00	0.00

	Sto. Tomas	Rosario	Pugo	Tubao	Naguilian
Bamboos	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
Ricefield, upland	0.00	0.00	0.00	0.00	0.30
	0.00	0.00	0.00	0.00	0.02
	0.00	0.00	0.00	0.00	4.14
	0.00	0.00	0.00	0.00	0.31
Beach sands	0.48	0.00	0.00	0.00	0.00
	0.03	0.00	0.00	0.00	0.00
	9.22	0.00	0.00	0.00	0.00
	0.77	0.00	0.00	0.00	0.00
Riverwash	0.00	0.00	0.24	0.00	3.50
	0.00	0.00	0.02	0.00	0.24
	0.00	0.00	1.23	0.00	17.93
	0.00	0.00	0.55	0.00	3.68
Rice terraces	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
Grapes	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
Mango	0.00	0.00	0.00	0.00	1.28
	0.00	0.00	0.00	0.00	0.09
	0.00	0.00	0.00	0.00	50.59
	0.00	0.00	0.00	0.00	1.35
Vegetables, lowland	0.00	0.00	0.21	0.30	5.57
	0.00	0.00	0.01	0.02	0.39
	0.00	0.00	1.80	2.57	47.88
	0.00	0.00	0.48	0.53	5.87
Airport	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
Total	61.86	69.24	43.57	56.84	94.98
	4.31	4.82	3.03	3.96	6.61

	Burgos	Bagulin	San Gabriel	Santol	Sudipen	Total
Forest with associated landuses	0.00	0.00	40.47	61.04	28.29	166.40
	0.00	0.00	2.82	4.25	1.97	11.58
	0.00	0.00	24.32	36.68	17.00	
	0.00	0.00	26.00	54.10	41.06	
Grassland (>90% dominant)	2.61	1.57	5.72	12.16	6.47	94.08
	0.18	0.11	0.40	0.85	0.45	6.55
	2.78	1.67	6.08	12.92	6.88	
	4.15	2.21	3.68	10.78	9.39	
Ricefield, irrigated	1.28	1.99	2.52	8.57	9.10	309.91
	0.09	0.14	0.18	0.60	0.63	21.57
	0.41	0.64	0.81	2.77	2.94	
	2.04	2.80	1.62	7.60	13.20	
Grassland (70-90 dominant)	3.26	3.08	33.97	19.48	10.16	208.24
	0.23	0.21	2.36	1.36	0.71	14.50
	1.56	1.48	16.31	9.35	4.88	
	5.17	4.34	21.82	17.26	14.74	
Shrubs	25.68	63.23	68.63	9.31	8.01	372.31
	1.79	4.40	4.78	0.65	0.56	25.92
	6.90	16.98	18.43	2.50	2.15	
	40.77	89.25	44.08	8.25	11.62	
Coconut	0.00	0.00	0.00	0.00	0.00	4.91
	0.00	0.00	0.00	0.00	0.00	0.34
	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	
Built-up Areas	0.00	0.00	0.93	1.00	1.03	76.89
	0.00	0.00	0.06	0.07	0.07	5.35
	0.00	0.00	1.20	1.30	1.34	
	0.00	0.00	0.59	0.89	1.50	
Grassland (<70% dominant)	25.07	0.84	0.87	0.15	1.85	134.31
	1.74	0.06	0.06	0.01	0.13	9.35
	18.66	0.62	0.65	0.11	1.38	
	39.80	1.18	0.56	0.13	2.69	
Corn (>70% dominant)	0.00	0.00	0.00	0.00	0.00	2.96
	0.00	0.00	0.00	0.00	0.00	0.21
	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	
Fishponds	0.00	0.00	0.00	0.00	0.00	15.66
	0.00	0.00	0.00	0.00	0.00	1.09
	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	

	Burgos	Bagulin	San Gabriel	Santol	Sudipen	Total
Bamboos	0.00	0.00	0.00	0.00	0.00	0.84
	0.00	0.00	0.00	0.00	0.00	0.06
	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	
Ricefield, upland	1.87	0.00	2.57	0.00	0.19	7.22
	0.13	0.00	0.18	0.00	0.01	0.50
	25.88	0.00	35.61	0.00	2.69	
	2.96	0.00	1.65	0.00	0.28	
Beach sands	0.00	0.00	0.00	0.00	0.00	5.18
	0.00	0.00	0.00	0.00	0.00	0.36
	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	
Riverwash	0.00	0.15	0.00	1.12	3.81	19.49
	0.00	0.01	0.00	0.08	0.27	1.36
	0.00	0.77	0.00	5.75	19.54	
	0.00	0.21	0.00	0.99	5.53	
Rice terraces	1.96	0.00	0.00	0.00	0.00	2.84
	0.14	0.00	0.00	0.00	0.00	0.20
	68.95	0.00	0.00	0.00	0.00	
	3.11	0.00	0.00	0.00	0.00	
Grapes	0.00	0.00	0.00	0.00	0.00	0.93
	0.00	0.00	0.00	0.00	0.00	0.06
	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	
Mango	1.25	0.00	0.00	0.00	0.00	2.54
	0.09	0.00	0.00	0.00	0.00	0.18
	49.41	0.00	0.00	0.00	0.00	
	1.99	0.00	0.00	0.00	0.00	
Vegetables, lowland	0.00	0.00	0.00	0.00	0.00	11.64
	0.00	0.00	0.00	0.00	0.00	0.81
	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	
Airport	0.00	0.00	0.00	0.00	0.00	0.25
	0.00	0.00	0.00	0.00	0.00	0.02
	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	
Total	62.98	70.85	155.67	112.83	68.91	1,436.58
	4.38	4.93	10.84	7.85	4.80	

Area cross tabulation of the 1990 landuse map across the N sub-basins of Agno River Basin

Area (km sq)
Total %
Row %
Col %

Legend	N1	N2	N3	N4	N5	N6	N7	N8
Forest with Associated landuse	16.18 0.92 1.88 29.70	4.99 0.28 0.58 58.70	23.77 1.35 2.76 54.39	18.21 1.03 2.12 57.88	37.48 2.12 4.36 57.94	31.43 1.78 3.66 65.32	30.34 1.72 3.53 63.69	34.93 1.98 4.06 46.92
Grassland (90-100%)	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00
Paddy rice irrigated	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00
Grassland (70-90%)	0.45 0.03 0.08 0.82	0.00 0.00 0.00 0.00	4.83 0.27 0.88 11.04	6.23 0.35 1.14 19.80	18.16 1.03 3.32 28.08	15.67 0.89 2.87 32.57	8.41 0.48 1.54 17.65	27.40 1.55 5.01 36.81
Shrubs	0.30 0.02 0.32 0.55	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00
Built-up area	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00
Grassland (>70%)	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00
Riverwash	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 0.00 0.00

Legend	N1	N2	N3	N4	N5	N6	N7	N8
Rice terrace irrigated	0.00	0.00	0.00	0.04	2.20	1.02	1.94	10.95
	0.00	0.00	0.00	0.00	0.12	0.06	0.11	0.62
	0.00	0.00	0.00	0.14	6.91	3.20	6.11	34.46
	0.00	0.00	0.00	0.14	3.39	2.11	4.08	14.71
Vegetable terrace	37.54	3.51	15.10	6.98	6.84	0.00	3.38	0.00
	2.12	0.20	0.85	0.39	0.39	0.00	0.19	0.00
	49.47	4.63	19.90	9.19	9.02	0.00	4.45	0.00
	68.92	41.30	34.56	22.17	10.58	0.00	7.09	0.00
Mines	0.00	0.00	0.00	0.00	0.00	0.00	3.57	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	78.10	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	7.49	0.00
Fiiling pond	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reservoir	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.17
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.57
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.57
Total	54.46	8.50	43.69	31.46	64.68	48.12	47.64	74.44
	3.08	0.48	2.47	1.78	3.66	2.72	2.70	4.21

Legend	N9	N10	N11	N12	N13	N14	N15	N16
Forest with Associated landuse	57.69	38.91	112.25	27.28	20.08	40.26	56.39	6.17
	3.27	2.20	6.35	1.54	1.14	2.28	3.19	0.35
	6.71	4.53	13.06	3.17	2.34	4.68	6.56	0.72
	57.53	52.15	78.73	28.50	22.91	38.28	49.26	59.94
Grassland (90-100%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paddy rice irrigated	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grassland (70-90%)	35.66	28.32	30.06	35.39	53.55	49.60	47.13	4.12
	2.02	1.60	1.70	2.00	3.03	2.81	2.67	0.23
	6.53	5.18	5.50	6.48	9.80	9.08	8.63	0.75
	35.56	37.96	21.08	36.98	61.11	47.16	41.17	40.06
Shrubs	0.00	0.94	0.00	1.45	4.15	11.11	8.02	0.00
	0.00	0.05	0.00	0.08	0.24	0.63	0.45	0.00
	0.00	1.02	0.00	1.57	4.50	12.03	8.69	0.00
	0.00	1.26	0.00	1.51	4.74	10.57	7.01	0.00
Built-up area	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grassland (>70%)	0.00	3.93	0.00	27.96	6.93	0.00	1.99	0.00
	0.00	0.22	0.00	1.58	0.39	0.00	0.11	0.00
	0.00	8.51	0.00	60.56	15.01	0.00	4.30	0.00
	0.00	5.27	0.00	29.22	7.91	0.00	1.74	0.00
Riverwash	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rice terrace irrigated	6.65	0.00	0.27	0.48	2.09	4.14	0.48	0.00
	0.38	0.00	0.02	0.03	0.12	0.23	0.03	0.00
	20.92	0.00	0.85	1.50	6.58	13.02	1.50	0.00
	6.63	0.00	0.19	0.50	2.39	3.93	0.42	0.00
Vegetable terrace	0.00	0.63	0.00	0.00	0.63	0.00	0.00	0.00
	0.00	0.04	0.00	0.00	0.04	0.00	0.00	0.00
	0.00	0.83	0.00	0.00	0.83	0.00	0.00	0.00
	0.00	0.84	0.00	0.00	0.72	0.00	0.00	0.00

Legend	N9	N10	N11	N12	N13	N14	N15	N16
Mines	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	1.96	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00
Filling pond	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00
Reservoir	0.28	1.88	0.00	3.05	0.19	0.06	0.00	0.00
	0.02	0.11	0.00	0.17	0.01	0.00	0.00	0.00
	4.28	28.38	0.00	45.95	2.93	0.90	0.00	0.00
	0.28	2.52	0.00	3.18	0.22	0.06	0.00	0.00
Total	100.28	74.62	142.57	95.69	87.63	105.17	114.47	10.29
	5.68	4.22	8.07	5.42	4.96	5.95	6.48	0.58

Legend	N17	N18	N19	N20	N21	N22	N23	N24
Forest with	23.27	1.43	4.12	0.18	3.23	2.82	0.70	14.85
Associated	1.32	0.08	0.23	0.01	0.18	0.16	0.04	0.84
landuse	2.71	0.17	0.48	0.02	0.38	0.33	0.08	1.73
	42.03	11.55	81.90	0.64	16.00	14.09	20.61	96.88
Grassland	22.51	0.00	0.00	0.57	0.18	3.53	0.00	0.00
(90-100%)	1.27	0.00	0.00	0.03	0.01	0.20	0.00	0.00
	37.50	0.00	0.00	0.95	0.30	5.87	0.00	0.00
	40.65	0.00	0.00	2.03	0.89	17.60	0.00	0.00
Paddy rice	1.73	0.00	0.00	1.72	0.00	2.60	0.00	0.00
irrigated	0.10	0.00	0.00	0.10	0.00	0.15	0.00	0.00
	4.64	0.00	0.00	4.60	0.00	6.96	0.00	0.00
	3.13	0.00	0.00	6.16	0.00	12.98	0.00	0.00
Grassland	7.86	10.98	0.91	25.44	16.76	3.45	0.00	0.00
(70-90%)	0.44	0.62	0.05	1.44	0.95	0.20	0.00	0.00
	1.44	2.01	0.17	4.66	3.07	0.63	0.00	0.00
	14.19	88.45	18.10	91.17	83.11	17.23	0.00	0.00
Shrubs	0.00	0.00	0.00	0.00	0.00	7.50	2.70	0.48
	0.00	0.00	0.00	0.00	0.00	0.42	0.15	0.03
	0.00	0.00	0.00	0.00	0.00	8.12	2.93	0.52
	0.00	0.00	0.00	0.00	0.00	37.43	79.39	3.12
Built-up area	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	3.93	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.00
Grassland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(>70%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Riverwash	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rice terrace	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
irrigated	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vegetable	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
terrace	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Legend	N17	N18	N19	N20	N21	N22	N23	N24
Mines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fiiling pond	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reservoir	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	55.38	12.41	5.03	27.90	20.17	20.03	3.41	15.33
	3.13	0.70	0.28	1.58	1.14	1.13	0.19	0.87

Legend	N25	N26	N27	N28	N29	N30	N31	N32
Forest with Associated landuse	9.65	21.36	27.13	47.76	4.26	3.05	5.54	8.69
	0.55	1.21	1.54	2.70	0.24	0.17	0.31	0.49
	1.12	2.48	3.16	5.56	0.50	0.35	0.64	1.01
	39.83	100.00	96.54	92.40	65.52	29.82	38.17	66.06
Grassland (90-100%)	0.00	0.00	0.88	0.00	0.00	6.45	0.30	2.76
	0.00	0.00	0.05	0.00	0.00	0.37	0.02	0.16
	0.00	0.00	1.47	0.00	0.00	10.75	0.50	4.60
	0.00	0.00	3.14	0.00	0.00	63.16	2.06	21.00
Paddy rice irrigated	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grassland (70-90%)	0.67	0.00	0.00	3.93	2.24	0.06	8.59	1.06
	0.04	0.00	0.00	0.22	0.13	0.00	0.49	0.06
	0.12	0.00	0.00	0.72	0.41	0.01	1.57	0.19
	2.77	0.00	0.00	7.60	34.48	0.58	59.16	8.06
Shrubs	13.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	15.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	57.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Built-up area	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grassland (>70%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Riverwash	0.00	0.00	0.09	0.00	0.00	0.66	0.09	0.64
	0.00	0.00	0.01	0.00	0.00	0.04	0.01	0.04
	0.00	0.00	4.35	0.00	0.00	31.88	4.35	31.16
	0.00	0.00	0.32	0.00	0.00	6.43	0.62	4.88
Rice terrace irrigated	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vegetable terrace	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Legend	N25	N26	N27	N28	N29	N30	N31	N32
Mines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fiiling pond	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reservoir	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	24.23	21.36	28.10	51.69	6.50	10.22	14.52	13.16
	1.37	1.21	1.59	2.93	0.37	0.58	0.82	0.74

Legend	N33	N34	N35	N36	N37	Total
Forest with Associated landuse	17.42	38.18	28.92	40.77	0.03	859.71
	0.99	2.16	1.64	2.31	0.00	48.66
	2.03	4.44	3.36	4.74	0.00	
	55.44	62.16	38.27	41.08	0.05	
Grassland (90-100%)	0.00	5.60	0.00	0.00	17.25	60.04
	0.00	0.32	0.00	0.00	0.98	3.40
	0.00	9.33	0.00	0.00	28.74	
	0.00	9.12	0.00	0.00	26.15	
Paddy rice irrigated	0.00	0.97	0.00	0.34	29.98	37.35
	0.00	0.05	0.00	0.02	1.70	2.11
	0.00	2.60	0.00	0.92	80.28	
	0.00	1.58	0.00	0.35	45.45	
Grassland (70-90%)	12.25	14.53	42.99	24.33	5.29	546.32
	0.69	0.82	2.43	1.38	0.30	30.92
	2.24	2.66	7.87	4.45	0.97	
	38.99	23.66	56.89	24.52	8.02	
Shrubs	1.52	0.10	0.18	29.77	10.22	92.36
	0.09	0.01	0.01	1.69	0.58	5.23
	1.65	0.11	0.19	32.23	11.06	
	4.85	0.17	0.24	30.00	15.49	
Built-up area	0.00	0.00	0.00	0.25	3.03	3.42
	0.00	0.00	0.00	0.01	0.17	0.19
	0.00	0.00	0.00	7.42	88.65	
	0.00	0.00	0.00	0.26	4.60	
Grassland (>70%)	0.00	1.61	0.67	3.08	0.00	46.17
	0.00	0.09	0.04	0.17	0.00	2.61
	0.00	3.49	1.46	6.66	0.00	
	0.00	2.63	0.89	3.10	0.00	
Riverwash	0.00	0.42	0.00	0.00	0.16	2.06
	0.00	0.02	0.00	0.00	0.01	0.12
	0.00	20.29	0.00	0.00	7.97	
	0.00	0.68	0.00	0.00	0.25	
Rice terrace irrigated	0.00	0.00	1.52	0.00	0.00	31.77
	0.00	0.00	0.09	0.00	0.00	1.80
	0.00	0.00	4.80	0.00	0.00	
	0.00	0.00	2.02	0.00	0.00	
Vegetable terrace	0.00	0.00	1.28	0.00	0.00	75.89
	0.00	0.00	0.07	0.00	0.00	4.30
	0.00	0.00	1.69	0.00	0.00	
	0.00	0.00	1.70	0.00	0.00	

Legend	N33	N34	N35	N36	N37	Total
Mines	0.22	0.00	0.00	0.69	0.00	4.57
	0.01	0.00	0.00	0.04	0.00	0.26
	4.90	0.00	0.00	15.03	0.00	
	0.71	0.00	0.00	0.69	0.00	
Filling pond	0.00	0.00	0.00	0.00	0.00	0.46
	0.00	0.00	0.00	0.00	0.00	0.03
	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	
Reservoir	0.00	0.00	0.00	0.00	0.00	6.63
	0.00	0.00	0.00	0.00	0.00	0.38
	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	
Total	31.42	61.43	75.57	99.23	65.97	1,766.76
	1.78	3.48	4.28	5.62	3.73	

Area cross tabulation of the 1990 landuse map across the Central Plain and S sub-basins of the Agno River Basin

Area (km sq)
Total %
Row %
Col %

Legend	Central Plain	S1	S2	S3	S4	S5	S6	S7
Forest	3.60	24.63	16.87	4.53	0.00	183.64	91.86	0.00
	0.06	0.41	0.28	0.08	0.00	3.05	1.52	0.00
	0.70	4.79	3.28	0.88	0.00	35.73	17.87	0.00
	0.09	23.63	44.54	3.82	0.00	82.18	34.51	0.00
Forest with Associated Landuse	44.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	35.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grassland (90-100%)	192.23	19.67	0.00	8.34	0.00	0.00	34.18	10.28
	3.19	0.33	0.00	0.14	0.00	0.00	0.57	0.17
	43.45	4.45	0.00	1.88	0.00	0.00	7.73	2.32
	4.71	18.88	0.00	7.04	0.00	0.00	12.84	29.50
Mangrove/ Nipa	20.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	78.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paddy rice irrigated	2,428.93	0.78	0.00	36.79	16.49	0.00	37.79	4.45
	40.31	0.01	0.00	0.61	0.27	0.00	0.63	0.07
	86.49	0.03	0.00	1.31	0.59	0.00	1.35	0.16
	59.47	0.75	0.00	31.09	40.20	0.00	14.20	12.78
Grassland (70-90%)	5.95	0.00	0.00	5.24	14.77	0.00	50.03	17.34
	0.10	0.00	0.00	0.09	0.25	0.00	0.83	0.29
	4.58	0.00	0.00	4.04	11.39	0.00	38.58	13.37
	0.15	0.00	0.00	4.43	36.02	0.00	18.79	49.79
Shrubs	38.93	0.00	0.00	0.00	0.00	17.25	0.00	0.00
	0.65	0.00	0.00	0.00	0.00	0.29	0.00	0.00
	67.37	0.00	0.00	0.00	0.00	29.86	0.00	0.00
	0.95	0.00	0.00	0.00	0.00	7.72	0.00	0.00
Coconut	88.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	97.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Legend	Central Plain	S1	S2	S3	S4	S5	S6	S7
Built-up	303.08	0.00	0.00	0.46	0.00	0.00	0.00	0.00
	5.03	0.00	0.00	0.01	0.00	0.00	0.00	0.00
	92.80	0.00	0.00	0.14	0.00	0.00	0.00	0.00
	7.42	0.00	0.00	0.39	0.00	0.00	0.00	0.00
Coffee	2.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cassava	83.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sugarcane	322.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	99.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grassland (>70%)	298.41	53.12	21.00	56.06	3.08	14.71	40.90	0.00
	4.95	0.88	0.35	0.93	0.05	0.24	0.68	0.00
	38.24	6.81	2.69	7.18	0.39	1.89	5.24	0.00
	7.31	50.97	55.46	47.37	7.50	6.58	15.36	0.00
Corn (>70%)	13.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fishpond	87.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	97.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Beachsand	4.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Riverwash	127.59	6.02	0.00	6.92	6.68	7.86	11.44	2.76
	2.12	0.10	0.00	0.11	0.11	0.13	0.19	0.05
	67.87	3.20	0.00	3.68	3.55	4.18	6.09	1.47
	3.12	5.78	0.00	5.84	16.28	3.52	4.30	7.93

Legend	Central Plain	S1	S2	S3	S4	S5	S6	S7
Mango	2.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Swamp	14.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	4,084.21	104.22	37.87	118.34	41.02	223.46	266.20	34.84
	67.79	1.73	0.63	1.96	0.68	3.71	4.42	0.58

Legend	S8	S9	S10	S11	S12	S13	S14	S15
Forest	0.00	148.50	12.95	0.66	0.04	22.14	4.57	0.00
	0.00	2.46	0.21	0.01	0.00	0.37	0.08	0.00
	0.00	28.89	2.52	0.13	0.01	4.31	0.89	0.00
	0.00	97.07	42.29	1.21	0.03	20.09	12.36	0.00
Forest with	0.00	0.00	0.00	0.00	0.00	0.00	18.43	12.20
Associated	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.20
Landuse	0.00	0.00	0.00	0.00	0.00	0.00	14.82	9.81
	0.00	0.00	0.00	0.00	0.00	0.00	49.84	23.06
Grassland	13.18	1.42	14.36	21.27	70.11	52.97	4.42	0.00
(90-100%)	0.22	0.02	0.24	0.35	1.16	0.88	0.07	0.00
	2.98	0.32	3.24	4.81	15.80	11.97	1.00	0.00
	11.39	0.93	46.88	39.05	54.41	48.08	11.95	0.00
Mangrove/	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nipa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paddy rice	57.45	0.00	0.00	29.11	47.70	34.07	2.12	0.00
irrigated	0.95	0.00	0.00	0.48	0.79	0.57	0.04	0.00
	2.05	0.00	0.00	1.04	1.70	1.21	0.08	0.00
	49.65	0.00	0.00	53.44	37.02	30.93	5.74	0.00
Grassland	36.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(70-90%)	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	28.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	31.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Shrubs	0.00	1.60	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	2.77	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	1.04	0.00	0.00	0.00	0.00	0.00	0.00
Coconut	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Built-up	2.67	0.00	0.00	0.06	8.78	0.24	0.00	0.00
	0.04	0.00	0.00	0.00	0.15	0.00	0.00	0.00
	0.82	0.00	0.00	0.02	2.69	0.07	0.00	0.00
	2.31	0.00	0.00	0.11	6.82	0.22	0.00	0.00

Legend	S8	S9	S10	S11	S12	S13	S14	S15
Coffee	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cassava	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sugarcane	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grassland	0.00	0.00	0.00	0.00	0.00	0.04	7.44	40.72
(>70%)	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.68
	0.00	0.00	0.00	0.00	0.00	0.01	0.95	5.22
	0.00	0.00	0.00	0.00	0.00	0.04	20.11	76.94
Corn (>70%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fishpond	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Beachsand	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Riverwash	5.80	1.46	3.32	3.38	2.21	0.70	0.00	0.00
	0.10	0.02	0.06	0.06	0.04	0.01	0.00	0.00
	3.08	0.78	1.76	1.80	1.18	0.37	0.00	0.00
	5.01	0.96	10.83	6.20	1.72	0.64	0.00	0.00
Mango	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Legend	S8	S9	S10	S11	S12	S13	S14	S15
Swamp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	115.71	152.98	30.62	54.48	128.84	110.17	36.99	52.93
	1.92	2.54	0.51	0.90	2.14	1.83	0.61	0.88

Legend	S16	S17	S18	S19	S20	S21	S22	Total
Forest	0.00	0.00	0.00	0.00	0.00	0.00	0.00	513.98
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.53
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Forest with	15.88	0.00	9.98	2.33	3.48	11.19	6.23	124.35
Associated	0.26	0.00	0.17	0.04	0.06	0.19	0.10	2.06
Landuse	12.77	0.00	8.02	1.87	2.80	9.00	5.01	
	39.56	0.00	23.12	4.28	2.81	11.12	10.71	
Grassland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	442.41
(90-100%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.34
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Mangrove/	0.00	0.00	0.00	0.00	0.30	5.11	0.28	26.07
Nipa	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.43
	0.00	0.00	0.00	0.00	1.15	19.60	0.09	
	0.00	0.00	0.00	0.00	0.24	5.08	0.49	
Paddy rice	5.95	0.00	0.24	24.02	38.65	29.65	14.21	2,808.41
irrigated	0.10	0.00	0.00	0.40	0.64	0.49	0.24	46.61
	0.21	0.00	0.01	0.86	1.38	1.06	0.51	
	14.81	0.00	0.55	44.08	31.21	29.47	24.42	
Grassland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	129.68
(70-90%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.15
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Shrubs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	57.78
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.96
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Coconut	0.00	0.00	0.00	0.00	0.67	0.87	0.63	90.88
	0.00	0.00	0.00	0.00	0.01	0.01	0.01	1.51
	0.00	0.00	0.00	0.00	0.74	0.95	0.69	
	0.00	0.00	0.00	0.00	0.54	0.86	1.08	
Built-up	0.81	0.00	0.00	1.90	3.23	3.76	1.61	326.61
	0.01	0.00	0.00	0.03	0.05	0.06	0.03	5.42
	0.25	0.00	0.00	0.58	0.99	1.15	0.49	
	2.01	0.00	0.00	3.48	2.61	3.74	2.77	

Legend	S16	S17	S18	S19	S20	S21	S22	Total
Coffee	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.29
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Cassava	0.00	0.00	0.00	0.00	0.00	0.00	0.00	83.86
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.39
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Sugarcane	0.00	0.00	0.00	0.00	0.00	0.09	2.30	325.13
	0.00	0.00	0.00	0.00	0.00	0.00	0.04	5.40
	0.00	0.00	0.00	0.00	0.00	0.03	0.71	
	0.00	0.00	0.00	0.00	0.00	0.09	3.95	
Grassland (>70%)	16.45	11.43	32.94	25.68	77.47	49.95	31.03	780.44
	0.27	0.19	0.55	0.43	1.29	0.83	0.51	12.95
	2.11	1.46	4.22	3.29	9.93	6.40	3.98	
	40.98	98.20	76.32	47.12	62.57	49.64	53.32	
Corn (>70%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.80
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Fishpond	0.00	0.00	0.00	0.00	0.00	0.00	1.90	89.69
	0.00	0.00	0.00	0.00	0.00	0.00	0.03	1.49
	0.00	0.00	0.00	0.00	0.00	0.00	2.12	
	0.00	0.00	0.00	0.00	0.00	0.00	3.26	
Beachsand	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.30
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Riverwash	1.06	0.21	0.00	0.57	0.01	0.00	0.00	187.98
	0.02	0.00	0.00	0.01	0.00	0.00	0.00	3.12
	0.56	0.11	0.00	0.30	0.01	0.00	0.00	
	2.64	1.80	0.00	1.04	0.01	0.00	0.00	
Mango	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.55
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

Legend	S16	S17	S18	S19	S20	S21	S22	Total
Swamp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.71
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Total	40.14	11.64	43.16	54.49	123.81	100.62	58.18	6,024.93
	0.67	0.19	0.72	0.90	2.05	1.67	0.97	

Tables on single area and

area cross tabulation analysis

1981-1990 landuse change for

(old growth dipterocarp) virgin forests

Area analysis on land use changes within virgin forest areas (dipterocarp) between 1981-1990.

Class	Land Use Change	Area (%)	Cumm (%)	Area (km sq.)
1	Virgin to Forest	25.460	25.460	114.681
2	Virgin to Forest w/ associated landuses	39.050	64.510	175.913
3	Virgin to Agricultural areas	4.370	68.880	19.674
5	Virgin to Riverwash	0.070	68.940	0.299
11	Virgin to Brushland/Grassland	31.060	100.000	139.897
Total of 5 classes		100.000		450.464

Area cross tabulation of the 1981-1990 landuse change for virgin (dipterocarp) forest across the N sub-basins of the Agno River Basin

Area (km sq)
Total %
Row %
Col %

Legend	N1	N3	N4	N5	N6	N9	N11	N17	N18
Virgin to	4.511	10.382	5.871	7.633	9.740	5.856	1.643	1.658	0.493
Forest with	3.850	8.860	5.010	6.510	8.310	5.000	1.400	1.410	0.420
Associated	4.760	10.940	6.190	8.050	10.270	6.170	1.730	1.750	0.520
Landuse	63.710	92.300	86.750	90.760	91.190	97.270	62.860	80.430	42.860
Virgin to	2.569	0.866	0.045	0.777	0.000	0.015	0.000	0.000	0.000
Agriculture	2.190	0.740	0.040	0.660	0.000	0.010	0.000	0.000	0.000
	60.140	20.280	1.050	18.180	0.000	0.350	0.000	0.000	0.000
	36.290	7.700	0.660	9.240	0.000	0.250	0.000	0.000	0.000
Virgin to	0.000	0.000	0.851	0.000	0.941	0.149	0.971	0.403	0.657
Brushland	0.000	0.000	0.730	0.000	0.800	0.130	0.830	0.340	0.560
	0.000	0.000	4.720	0.000	5.220	0.830	5.380	2.240	3.640
	0.000	0.000	12.580	0.000	8.810	2.480	37.140	19.570	57.140
Total	7.081	11.249	6.767	8.410	10.681	6.020	2.614	2.061	1.150
	6.040	9.600	5.770	7.180	9.110	5.140	2.230	1.760	0.980

Legend	N21	N22	N23	N24	N25	N26	N27	N34	Total
Virgin to	0.538	0.000	0.702	14.849	7.200	19.375	4.198	0.224	94.873
Forest with	0.460	0.000	0.600	12.670	6.140	16.530	3.580	0.190	80.960
Associated	0.570	0.000	0.740	15.650	7.590	20.420	4.420	0.240	
Landuse	12.810	0.000	20.610	96.880	69.450	100.000	100.000	9.490	
Virgin to	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	4.272
Agriculture	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	3.650
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
Virgin to	3.660	1.927	2.704	0.478	3.167	0.000	0.000	2.136	18.045
Brushland	3.120	1.640	2.310	0.410	2.700	0.000	0.000	1.820	15.400
	20.280	10.680	14.980	2.650	17.550	0.000	0.000	11.840	
	87.190	100.000	79.390	3.120	30.550	0.000	0.000	90.510	
Total	4.198	1.927	3.406	15.327	10.367	19.375	4.198	2.360	117.191
	3.580	1.640	2.910	13.080	8.850	16.530	3.580	2.010	

Area cross tabulation of the 1981-1990 landuse change for virgin (dipterocarp) forest across the Central Plain and S sub-basins of the Agno River Basin

Area (km sq)
Total %
Row %
Col %

Legend	Central Plain	S1	S5	S6	S9	S13	S14	S15	S6	S17	S18	Total
Forest	0.000	0.060	43.157	2.241	38.242	7.424	1.434	0.000	0.000	0.000	0.000	92.558
	0.000	0.040	25.790	1.340	22.860	4.440	0.860	0.000	0.000	0.000	0.000	55.320
	0.000	0.060	46.630	2.420	41.320	8.020	1.550	0.000	0.000	0.000	0.000	
	0.000	100.000	72.080	96.770	97.340	100.000	16.130	0.000	0.000	0.000	0.000	
Forest with	15.610	0.000	0.000	0.000	0.000	0.000	7.380	6.558	5.677	0.000	0.732	35.956
Associated	9.330	0.000	0.000	0.000	0.000	0.000	4.410	3.920	3.390	0.000	0.440	21.490
Landuse	43.420	0.000	0.000	0.000	0.000	0.000	20.520	18.240	15.790	0.000	2.040	
	55.790	0.000	0.000	0.000	0.000	0.000	83.030	43.990	99.220	0.000	100.000	
Riverwash	0.000	0.000	0.299	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.299
	0.000	0.000	0.180	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.180
	0.000	0.000	100.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
	0.000	0.000	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
Brushland	12.369	0.000	16.417	0.075	1.046	0.000	0.075	8.350	0.045	0.134	0.000	38.511
	7.390	0.000	9.810	0.040	0.620	0.000	0.040	4.990	0.030	0.080	0.000	23.020
	32.120	0.000	42.630	0.190	2.720	0.000	0.190	21.680	0.120	0.350	0.000	
	44.210	0.000	27.420	3.230	2.660	0.000	0.840	56.010	0.780	100.000	0.000	
Total	27.979	0.060	59.873	2.315	39.288	7.424	8.888	14.908	5.721	0.134	0.732	167.324
	16.720	0.040	35.780	1.380	23.480	4.440	5.310	8.910	3.420	0.080	0.440	

Area cross tabulation of the 1981-1990 landuse change for virgin (old growth dipterocarp) forest within the municipalities of Pangasinan.

Area (km sq)
Total %
Row %
Col %

Municipality	Forest	Forest w/ Associated Landuses	Brushland	Total
Labrador	0.000	0.060	0.164	0.224
	0.000	0.040	0.120	0.170
	0.000	26.670	73.330	
	0.000	0.070	0.390	
Mabini	0.000	0.000	6.543	6.543
	0.000	0.000	4.880	4.880
	0.000	0.000	100.000	
	0.000	0.000	15.610	
Aguilar	0.000	0.717	0.000	0.717
	0.000	0.530	0.000	0.530
	0.000	100.000	0.000	
	0.000	0.850	0.000	
Mangatarem	7.394	19.614	8.604	35.613
	5.520	14.630	6.420	26.570
	20.760	55.080	24.160	
	100.000	23.140	20.530	
Sison	0.000	0.164	1.808	1.972
	0.000	0.120	1.350	1.470
	0.000	8.330	91.670	
	0.000	0.190	4.310	
San Manuel	0.000	0.015	0.090	0.105
	0.000	0.010	0.070	0.080
	0.000	14.290	85.710	
	0.000	0.020	0.210	
San Nicolas	0.000	2.211	5.901	8.111
	0.000	1.650	4.400	6.050
	0.000	27.260	72.740	
	0.000	2.610	14.080	
Natividad	0.000	23.468	13.146	36.614
	0.000	17.510	9.810	27.320
	0.000	64.100	35.900	
	0.000	27.690	31.370	

Municipality	Forest	Forest w/ Associated Landuses	Brushland	Total
San Quintin	0.000	37.107	5.647	42.753
	0.000	27.680	4.210	31.900
	0.000	86.790	13.210	
	0.000	43.790	13.480	
Umingan	0.000	1.389	0.000	1.389
	0.000	1.040	0.000	1.040
	0.000	100.000	0.000	
	0.000	1.640	0.000	
Total	7.394	84.745	41.902	134.041
	5.520	63.220	31.260	

Area cross tabulation of the 1981-1990 landuse change for virgin (old growth dipterocarp) forest within the municipalities of Benguet.

Area (km sq)
Total %
Row %
Col %

Municipality	Forest w/ Associated Landuses	Agricultural Areas	Brushland	Total
Bakun	11.951	0.359	7.678	19.987
	8.450	0.250	5.430	14.130
	59.790	1.790	38.420	
	14.350	2.070	18.810	
Mankayan	13.056	8.111	0.448	21.616
	9.230	5.740	0.320	15.280
	60.400	37.530	2.070	
	15.680	46.770	1.100	
Buguias	10.263	3.286	0.284	13.833
	7.260	2.320	0.200	9.780
	74.190	23.760	2.050	
	12.330	18.950	0.700	
Kibungan	12.653	3.406	1.150	17.209
	8.950	2.410	0.810	12.170
	73.520	19.790	6.680	
	15.200	19.640	2.820	
Kabayan	27.412	1.001	1.225	29.638
	19.380	0.710	0.870	20.950
	92.490	3.380	4.130	
	32.920	5.770	3.000	
Atok	0.762	1.165	0.373	2.300
	0.540	0.820	0.260	1.630
	33.120	50.650	16.230	
	0.910	6.720	0.910	
Kapangan	0.000	0.000	21.138	21.138
	0.000	0.000	14.950	14.950
	0.000	0.000	100.000	
	0.000	0.000	51.770	
Tublay	0.000	0.000	3.361	3.361
	0.000	0.000	2.380	2.380
	0.000	0.000	100.000	
	0.000	0.000	8.230	

Municipality	Forest w/ Associated Landuses	Agricultural Areas	Brushland	Total
Sablan	0.000	0.000	2.853	2.853
	0.000	0.000	2.020	2.020
	0.000	0.000	100.000	
	0.000	0.000	6.990	
Tuba	0.060	0.000	0.538	0.598
	0.040	0.000	0.380	0.420
	10.000	0.000	90.000	
	0.070	0.000	1.320	
Itogon	2.136	0.000	1.628	3.764
	1.510	0.000	1.150	2.660
	56.750	0.000	43.250	
	2.570	0.000	3.990	
Bokod	4.974	0.015	0.149	5.139
	3.520	0.010	0.110	3.630
	96.800	0.290	2.910	
	5.970	0.090	0.370	
Total	83.266	17.343	40.826	141.436
	58.870	12.260	28.870	

Area cross tabulation of the 1981-1990 landuse change for virgin (old growth dipterocarp) forest within the municipalities of Tarlac.

Area (km sq)
Total %
Row %
Col %

Municipality	Forest	Riverwash	Brushland	Total
Camp O'Donnel	6.603	0.000	0.284	6.887
	4.550	0.000	0.200	4.740
	95.880	0.000	4.120	
	5.960	0.000	0.830	
Tarlac	75.140	0.299	33.970	109.408
	51.730	0.210	23.390	75.320
	68.680	0.270	31.050	
	67.870	100.000	99.170	
Mayantoc	26.829	0.000	0.000	26.829
	18.470	0.000	0.000	18.470
	100.000	0.000	0.000	
	24.230	0.000	0.000	
San Clemente	2.136	0.000	0.000	2.136
	1.470	0.000	0.000	1.470
	100.000	0.000	0.000	
	1.930	0.000	0.000	
Total	110.708	0.299	34.253	145.260
	76.210	0.210	23.580	

Area cross tabulation of the 1981-1990 landuse change for virgin (old growth dipterocar forest within the municipalities of La Union.

Area (km sq)
Total %
Row %
Col %

Municipality	Forest w/ Associated Landuses	Agricultural Areas	Brushland	Total
Burgos	0.0000	1.0009	5.6317	6.6326
	0.0000	2.7800	15.6700	18.4500
	0.0000	15.0900	84.9100	
	0.0000	42.9500	21.8800	
Bagulin	0.0000	0.0000	3.0922	3.0922
	0.0000	0.0000	8.6000	8.6000
	0.0000	0.0000	100.0000	
	0.0000	0.0000	12.0100	
San Gabriel	0.2689	1.0307	12.7872	14.0868
	0.7500	2.8700	35.5800	39.1900
	1.9100	7.3200	90.7700	
	3.4200	44.2300	49.6800	
Santol	1.6731	0.0000	2.1660	3.8391
	4.6600	0.0000	6.0300	10.6800
	43.5800	0.0000	56.4200	
	21.2500	0.0000	8.4200	
Sudipen	5.9305	0.2988	2.0615	8.2907
	16.5000	0.8300	5.7400	23.0700
	71.5300	3.6000	24.8600	
	75.3300	12.8200	8.0100	
Total	7.8725	2.3304	25.7386	35.9415
	21.9000	6.4800	71.6100	

Tables on single area and area cross tabulation analysis for 1981-1990 landuse change for (old growth dipterocarp) residual forests

Area analysis on land use changes within residual forest areas (dipterocarp) between 1981-1990.

Class	Land Use Change	Area (%)	Cumm (%)	Area (km sq.)
1	Residual to Forest area	32.160	32.160	276.059
2	Residual to Forest w/ associated landuses	21.920	54.080	188.207
3	Residual to Agricultural areas	2.300	56.380	19.719
5	Residual to Riverwash	0.690	57.060	5.901
8	Residual to Mines	0.000	57.070	0.015
11	Residual to Brush/Grassland	42.930	100.000	368.587
	Total of 6 classes	100.000		858.488

Area cross tabulation of the 1981-1990 landuse change for residual (dipterocarp) forest across the N sub-basins of the Agno River System

Area (km sq)
Total %
Row %
Col %

Legend	N1	N3	N4	N5	N6	N9	N10	N11	N13	N14	N15	N17
Forest with	0.4631	0.9262	0.2689	0.5378	5.4077	1.9569	0.0000	3.2416	0.0149	0.0000	2.1212	7.9023
Associated	0.5400	1.0900	0.3200	0.6300	6.3600	2.3000	0.0000	3.8100	0.0200	0.0000	2.4900	9.2900
Landuse	0.9500	1.9000	0.5500	1.1000	11.1000	4.0200	0.0000	6.6600	0.0300	0.0000	4.3600	16.2300
	48.4400	74.7000	21.9500	51.4300	87.8600	72.3800	0.0000	100.0000	4.5500	0.0000	81.1400	39.8600
Agriculture	0.4930	0.3137	0.8963	0.0448	0.1195	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1344
	0.5800	0.3700	1.0500	0.0500	0.1400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1600
	22.6000	14.3800	41.1000	2.0500	5.4800	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	6.1600
	51.5600	25.3000	73.1700	4.2900	1.9400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6800
Brushland	0.0000	0.0000	0.0598	0.4631	0.6274	0.7469	1.0756	0.0000	0.3137	1.5237	0.4930	11.7863
	0.0000	0.0000	0.0700	0.5400	0.7400	0.8800	1.2600	0.0000	0.3700	1.7900	0.5800	13.8600
	0.0000	0.0000	0.1700	1.3600	1.8400	2.1900	3.1500	0.0000	0.9200	4.4600	1.4400	34.5100
	0.0000	0.0000	4.8800	44.2900	10.1900	27.6200	100.0000	0.0000	95.4500	100.0000	18.8600	59.4600
Total	0.9560	1.2399	1.2249	1.0457	6.1546	2.7038	1.0756	3.2416	0.3286	1.5237	2.6142	19.8231
	1.1200	1.4600	1.4400	1.2300	7.2400	3.1800	1.2600	3.8100	0.3900	1.7900	3.0700	23.3100

Legend	N18	N20	N21	N22	N25	N26	N27	N28	N33	N34	N35	Total
Forest with	0.0299	0.1046	0.6125	2.0914	1.2548	0.1942	12.7125	0.1494	0.4033	4.1528	4.1528	48.6988
Associated	0.0400	0.1200	0.7200	2.4600	1.4800	0.2300	14.9500	0.1800	0.4700	4.8800	4.8800	57.2700
Landuse	0.0600	0.2100	1.2600	4.2900	2.5800	0.4000	26.1000	0.3100	0.8300	8.5300	8.5300	
	1.8500	3.4700	16.7300	43.8900	38.5300	100.0000	100.0000	100.0000	62.7900	54.1900	76.5800	
Agriculture	0.0000	0.0299	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1494	2.1810
	0.0000	0.0400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1800	2.5700
	0.0000	1.3700	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	6.8500	
	0.0000	0.9900	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	2.7500	
Brushland	1.5835	2.8831	3.0474	2.6740	2.0017	0.0000	0.0000	0.0000	0.2390	3.5105	1.1204	34.1489
	1.8600	3.3900	3.5800	3.1400	2.3500	0.0000	0.0000	0.0000	0.2800	4.1300	1.3200	40.1600
	4.6400	8.4400	8.9200	7.8300	5.8600	0.0000	0.0000	0.0000	0.7000	10.2800	3.2800	
	98.1500	95.5400	83.2700	56.1100	61.4700	0.0000	0.0000	0.0000	37.2100	45.8100	20.6600	
Total	1.6133	3.0175	3.6599	4.7653	3.2565	0.1942	12.7125	0.1494	0.6423	7.6633	5.4226	85.0286
	1.9000	3.5500	4.3000	5.6000	3.8300	0.2300	14.9500	0.1800	0.7600	9.0100	6.3800	

Area cross tabulation of the 1981-1990 landuse change for residual (dipterocarp) forest across the Central Plain and S sub-basins of the Agno River Basin

Area (km sq)
Total %
Row %
Col %

Legend	Central Plain	S1	S2	S3	S5
Forest	0.866	14.998	11.024	1.688	85.746
	0.220	3.760	2.760	0.420	21.490
	0.340	5.940	4.370	0.670	33.970
	5.510	75.380	81.640	96.580	89.790
Forest with	2.076	0.000	0.000	0.000	0.000
Associated	0.520	0.000	0.000	0.000	0.000
Landuse	6.170	0.000	0.000	0.000	0.000
	13.200	0.000	0.000	0.000	0.000
Agriculture	0.463	0.000	0.000	0.000	0.000
	0.120	0.000	0.000	0.000	0.000
	18.790	0.000	0.000	0.000	0.000
	2.940	0.000	0.000	0.000	0.000
Riverwash	0.911	0.000	0.000	0.000	3.077
	0.230	0.000	0.000	0.000	0.770
	16.140	0.000	0.000	0.000	54.500
	5.790	0.000	0.000	0.000	3.220
Brushland	11.413	4.900	2.480	0.060	6.677
	2.860	1.230	0.620	0.010	1.670
	10.880	4.670	2.360	0.060	6.370
	72.550	24.620	18.360	3.420	6.990
Total	15.730	19.898	13.504	1.748	95.500
	3.940	4.990	3.380	0.440	23.930

Legend	S6	S9	S10	S11	S12
Forest	71.838	53.494	4.750	0.254	0.045
	18.000	13.410	1.190	0.060	0.010
	28.460	21.190	1.880	0.100	0.020
	78.270	99.030	43.860	2.540	1.690
Forest with	0.000	0.000	0.000	0.000	0.000
Associated	0.000	0.000	0.000	0.000	0.000
Landuse	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000
Agriculture	0.000	0.000	0.000	0.881	0.284
	0.000	0.000	0.000	0.220	0.070
	0.000	0.000	0.000	35.760	11.520
	0.000	0.000	0.000	8.830	10.730
Riverwash	0.956	0.060	0.642	0.000	0.000
	0.240	0.010	0.160	0.000	0.000
	16.930	1.060	11.380	0.000	0.000
	1.040	0.110	5.930	0.000	0.000
Brushland	18.987	0.463	5.438	8.843	2.315
	4.760	0.120	1.360	2.220	0.580
	18.100	0.440	5.180	8.430	2.210
	20.690	0.860	50.210	88.620	87.570
Total	91.781	54.017	10.830	9.979	2.644
	23.000	13.540	2.710	2.500	0.660

Legend	S13	S14	S15	S16	S18
Forest	5.691	2.002	0.000	0.000	0.000
	1.430	0.500	0.000	0.000	0.000
	2.250	0.790	0.000	0.000	0.000
	27.040	19.620	0.000	0.000	0.000
Forest with	0.000	6.214	4.706	7.858	6.588
Associated	0.000	1.560	1.180	1.970	1.650
Landuse	0.000	18.470	13.990	23.360	19.580
	0.000	60.910	100.000	66.670	55.540
Agriculture	0.209	0.000	0.000	0.627	0.000
	0.050	0.000	0.000	0.160	0.000
	8.480	0.000	0.000	25.450	0.000
	0.990	0.000	0.000	5.320	0.000
Riverwash	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000
Brushland	15.147	1.987	0.000	3.301	5.273
	3.800	0.500	0.000	0.830	1.320
	14.440	1.890	0.000	3.150	5.030
	71.970	19.470	0.000	28.010	44.460
Total	21.048	10.203	4.706	11.786	11.861
	5.270	2.560	1.180	2.950	2.970

Legend	S19	S20	S21	S22	Total
Forest	0.000	0.000	0.000	0.000	252.397
	0.000	0.000	0.000	0.000	63.250
	0.000	0.000	0.000	0.000	
	0.000	0.000	0.000	0.000	
Forest with	1.882	0.373	1.897	2.047	33.641
Associated	0.470	0.090	0.480	0.510	8.430
Landuse	5.600	1.110	5.640	6.080	
	46.490	6.100	33.420	25.700	
Agriculture	0.000	0.000	0.000	0.000	2.465
	0.000	0.000	0.000	0.000	0.620
	0.000	0.000	0.000	0.000	
	0.000	0.000	0.000	0.000	
Riverwash	0.000	0.000	0.000	0.000	5.647
	0.000	0.000	0.000	0.000	1.420
	0.000	0.000	0.000	0.000	
	0.000	0.000	0.000	0.000	
Brushland	2.166	5.751	3.779	5.916	104.897
	0.540	1.440	0.950	1.480	26.290
	2.060	5.480	3.600	5.640	
	53.510	93.900	66.580	74.300	
Total	4.048	6.125	5.677	7.962	399.046
	1.010	1.530	1.420	2.000	

Area cross tabulation of the 1981-1990 landuse change for residual (dipterocarp) forest within the municipalities of Pangasinan.

Area (km sq)
Total %
Row %
Col%

Municipality	Forest	Forest w/ Associated Landuse	Agricultural Areas	Riverwash	Brushland	Total
Labrador	0.000	18.270	0.075	0.000	6.707	25.051
	0.000	9.800	0.040	0.000	3.600	13.440
	0.000	72.930	0.300	0.000	26.770	
	0.000	17.410	2.380	0.000	9.080	
Sual	0.000	0.000	1.793	0.000	4.870	6.662
	0.000	0.000	0.960	0.000	2.610	3.580
	0.000	0.000	26.910	0.000	73.090	
	0.000	0.000	57.140	0.000	6.600	
Mabini	0.000	2.211	0.000	0.000	0.015	2.226
	0.000	1.190	0.000	0.000	0.010	1.190
	0.000	99.330	0.000	0.000	0.670	
	0.000	2.110	0.000	0.000	0.020	
Infanta	0.000	27.875	0.000	0.000	4.272	32.147
	0.000	14.960	0.000	0.000	2.290	17.250
	0.000	86.710	0.000	0.000	13.290	
	0.000	26.570	0.000	0.000	5.790	
Bugallon	0.000	3.018	0.000	0.000	8.111	11.129
	0.000	1.620	0.000	0.000	4.350	5.970
	0.000	27.110	0.000	0.000	72.890	
	0.000	2.880	0.000	0.000	10.990	
Aguilar	0.000	11.099	0.000	0.000	7.992	19.091
	0.000	5.960	0.000	0.000	4.290	10.250
	0.000	58.140	0.000	0.000	41.860	
	0.000	10.580	0.000	0.000	10.820	
Mangatarem	3.540	14.460	0.777	0.000	5.990	24.768
	1.900	7.760	0.420	0.000	3.210	13.290
	14.290	58.380	3.140	0.000	24.190	
	100.000	13.780	24.760	0.000	8.110	
Sison	0.000	0.926	0.269	0.000	7.215	8.410
	0.000	0.500	0.140	0.000	3.870	4.510
	0.000	11.010	3.200	0.000	85.790	
	0.000	0.880	8.570	0.000	9.770	

Municipality	Forest	Forest w/ Associated Landuse	Agricultural Areas	Riverwash	Brushland	Total
San Manuel	0.000	1.598	0.000	0.105	2.241	3.944
	0.000	0.860	0.000	0.060	1.200	2.120
	0.000	40.530	0.000	2.650	56.820	
	0.000	1.520	0.000	11.480	3.030	
San Nicolas	0.000	12.264	0.224	0.807	24.454	37.749
	0.000	6.580	0.120	0.430	13.120	20.260
	0.000	32.490	0.590	2.140	64.780	
	0.000	11.690	7.140	88.520	33.120	
Natividad	0.000	0.030	0.000	0.000	1.583	1.613
	0.000	0.020	0.000	0.000	0.850	0.870
	0.000	1.850	0.000	0.000	98.150	
	0.000	0.030	0.000	0.000	2.140	
San Quintin	0.000	4.974	0.000	0.000	0.000	4.974
	0.000	2.670	0.000	0.000	0.000	2.670
	0.000	100.000	0.000	0.000	0.000	
	0.000	4.740	0.000	0.000	0.000	
Umingan	0.000	8.186	0.000	0.000	0.388	8.575
	0.000	4.390	0.000	0.000	0.210	4.600
	0.000	95.470	0.000	0.000	4.530	
	0.000	7.800	0.000	0.000	0.530	
Total	3.540	104.911	3.137	0.911	73.840	186.340
	1.900	56.300	1.680	0.490	39.630	

Area cross tabulation of the 1981-1990 landuse change for residual (dipterocarp) forest within the municipalities of Benguet.

Area (km sq)
Total %
Row %
Col %

Municipality	Forest w/ Associated Landuses	Agricultural Areas	Mines	Brushland	Total
Bakun	7.75	0.00	0.00	1.73	9.49
	3.94	0.00	0.00	0.88	4.82
	81.73	0.00	0.00	18.27	
	15.51	0.00	0.00	1.29	
Mankayan	0.63	0.15	0.00	0.43	1.21
	0.32	0.08	0.00	0.22	0.62
	51.85	12.35	0.00	35.80	
	1.26	1.20	0.00	0.32	
Buguias	1.60	1.84	0.00	0.06	3.50
	0.81	0.93	0.00	0.03	1.78
	45.73	52.56	0.00	1.71	
	3.20	14.78	0.00	0.04	
Kibungan	5.63	1.24	0.00	7.35	14.22
	2.86	0.63	0.00	3.74	7.23
	39.60	8.72	0.00	51.68	
	11.27	9.98	0.00	5.48	
Kabayan	5.90	0.48	0.00	1.03	7.41
	3.00	0.24	0.00	0.52	3.77
	79.64	6.45	0.00	13.91	
	11.81	3.85	0.00	0.77	
Atok	10.26	0.69	0.02	5.92	16.88
	5.22	0.35	0.01	3.01	8.58
	60.80	4.07	0.09	35.04	
	20.53	5.53	100.00	4.41	
Kapangan	0.13	1.60	0.00	39.14	40.87
	0.07	0.81	0.00	19.90	20.78
	0.33	3.91	0.00	95.76	
	0.27	12.86	0.00	29.16	
Tublay	0.00	6.01	0.00	11.91	17.91
	0.00	3.05	0.00	6.05	9.11
	0.00	33.53	0.00	66.47	
	0.00	48.32	0.00	8.87	

Municipality	Forest w/ Associated Landuses	Agricultural Areas	Mines	Brushland	Total
Sablan	1.17	0.00	0.00	42.57	43.74
	0.59	0.00	0.00	21.65	22.24
	2.66	0.00	0.00	97.34	
	2.33	0.00	0.00	31.72	
La Trinidad	0.00	0.22	0.00	3.85	4.08
	0.00	0.11	0.00	1.96	2.07
	0.00	5.49	0.00	94.51	
	0.00	1.80	0.00	2.87	
Tuba	3.91	0.06	0.00	13.68	17.66
	1.99	0.03	0.00	6.96	8.98
	22.17	0.34	0.00	77.50	
	7.83	0.48	0.00	10.19	
Baguio	5.11	0.15	0.00	1.00	6.26
	2.60	0.08	0.00	0.51	3.18
	81.62	2.39	0.00	15.99	
	10.22	1.20	0.00	0.75	
Itogon	2.39	0.00	0.00	3.68	6.07
	1.22	0.00	0.00	1.87	3.08
	39.41	0.00	0.00	60.59	
	4.78	0.00	0.00	2.74	
Bokod	5.50	0.00	0.00	1.88	7.38
	2.80	0.00	0.00	0.96	3.75
	74.49	0.00	0.00	25.51	
	11.00	0.00	0.00	1.40	
Total	49.98	12.43	0.02	134.24	196.66
	25.42	6.32	0.01	68.26	

Area cross tabulation of the 1981-1990 landuse change for residual (dipterocarp) forest within the municipalities of Tarlac.

Area (km sq)
Total %
Row %
Col %

Municipality	Forest	Forest w/ Associated Landuses	Agricultural Areas	Riverwash	Brushland	Total
Bamban	26.680	0.000	0.000	0.000	2.480	29.160
	7.690	0.000	0.000	0.000	0.720	8.410
	91.500	0.000	0.000	0.000	8.500	
	9.730	0.000	0.000	0.000	3.750	
O'Donnel	57.886	0.000	0.000	0.000	9.426	67.312
	16.690	0.000	0.000	0.000	2.720	19.410
	86.000	0.000	0.000	0.000	14.000	
	21.120	0.000	0.000	0.000	14.260	
Tarlac	109.020	0.000	0.000	4.033	19.898	132.951
	31.440	0.000	0.000	1.160	5.740	38.340
	82.000	0.000	0.000	3.030	14.970	
	39.770	0.000	0.000	85.170	30.110	
Mayantoc	80.009	0.000	1.165	0.702	32.595	114.472
	23.070	0.000	0.340	0.200	9.400	33.010
	69.890	0.000	1.020	0.610	28.470	
	29.190	0.000	84.780	14.830	49.320	
Camiling	0.000	0.000	0.000	0.000	0.045	0.045
	0.000	0.000	0.000	0.000	0.010	0.010
	0.000	0.000	0.000	0.000	100.000	
	0.000	0.000	0.000	0.000	0.070	
San Clemente	0.508	0.448	0.209	0.000	1.643	2.808
	0.150	0.130	0.060	0.000	0.470	0.810
	18.090	15.960	7.450	0.000	58.510	
	0.190	100.000	15.220	0.000	2.490	
Total	274.102	0.448	1.374	4.735	66.087	346.747
	79.050	0.130	0.400	1.370	19.060	

Municipality	Forest w/ Associated Landuse	Agricultural Areas	Riverwash	Brushland	Total
Santol	6.364	0.000	0.075	0.971	7.409
	4.610	0.000	0.050	0.700	5.370
	85.890	0.000	1.010	13.100	
	19.130	0.000	31.250	0.960	
Sudipen	0.478	0.553	0.164	1.285	2.480
	0.350	0.400	0.120	0.930	1.800
	19.280	22.290	6.630	51.810	
	1.440	19.370	68.750	1.270	
Total	33.268	2.853	0.239	101.535	137.895
	24.130	2.070	0.170	73.630	

Tables on single area and

area cross tabulation analysis for

1981-1990 landuse change for pine forests

Legend	N9	N10	N11	N12	N13	N14	N15	N16
Forest with	29.518	32.550	90.840	18.284	13.878	27.651	38.063	1.927
Associated	4.300	4.740	13.230	2.660	2.020	4.030	5.540	0.280
Landuse	6.930	7.640	21.310	4.290	3.260	6.490	8.930	0.450
	60.320	58.800	88.810	39.190	41.230	84.020	50.340	77.710
Agriculture	0.822	0.627	0.120	0.478	0.284	0.538	0.194	0.000
	0.120	0.090	0.020	0.070	0.040	0.080	0.030	0.000
	3.900	2.980	0.570	2.270	1.350	2.550	0.920	0.000
	1.680	1.130	0.120	1.020	0.840	1.630	0.260	0.000
Riverwash	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Reservoir	0.194	0.538	0.000	0.000	0.000	0.000	0.000	0.000
	0.030	0.080	0.000	0.000	0.000	0.000	0.000	0.000
	11.020	30.510	0.000	0.000	0.000	0.000	0.000	0.000
	0.400	0.970	0.000	0.000	0.000	0.000	0.000	0.000
Mines	0.000	0.000	0.000	0.090	0.000	0.000	0.105	0.000
	0.000	0.000	0.000	0.010	0.000	0.000	0.020	0.000
	0.000	0.000	0.000	4.720	0.000	0.000	5.510	0.000
	0.000	0.000	0.000	0.190	0.000	0.000	0.140	0.000
Brushland	18.404	21.646	11.323	27.800	19.494	4.720	37.256	0.553
	2.680	3.150	1.650	4.050	2.840	0.690	5.430	0.080
	7.830	9.210	4.820	11.820	8.290	2.010	15.850	0.240
	37.610	39.100	11.070	59.590	57.920	14.340	49.270	22.290
Total	48.938	55.361	102.282	46.652	33.656	32.909	75.618	2.480
	7.130	8.060	14.900	6.790	4.900	4.790	11.010	0.360

Area cross tabulation of the 1981-1990 landuse change
for pine forest across the N sub-basins of the Agno River Basin

Area (km sq)
Total %
Row %
Col %

Legend	N1	N2	N3	N4	N5	N6	N7	N8
Forest with	1.897	2.614	2.450	1.554	19.240	11.443	18.628	27.979
Associated	0.280	0.380	0.360	0.230	2.800	1.670	2.710	4.080
Landuse	0.450	0.610	0.570	0.360	4.510	2.680	4.370	6.560
	37.130	86.630	50.930	47.490	83.850	78.000	71.750	50.130
Agriculture	3.062	0.403	1.464	1.374	0.179	0.239	2.435	8.649
	0.450	0.060	0.210	0.200	0.030	0.030	0.350	1.260
	14.540	1.910	6.950	6.520	0.850	1.130	11.560	41.060
	59.940	13.370	30.430	42.010	0.780	1.630	9.380	15.500
Riverwash	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Reservoir	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.031
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.150
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	58.470
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.850
Mines	0.000	0.000	0.000	0.000	0.000	0.000	0.971	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.140	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	51.180	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	3.740	0.000
Brushland	0.149	0.000	0.896	0.344	3.525	2.988	3.929	18.150
	0.020	0.000	0.130	0.050	0.510	0.440	0.570	2.640
	0.060	0.000	0.380	0.150	1.500	1.270	1.670	7.720
	2.920	0.000	18.630	10.500	15.360	20.370	15.130	32.520
Total	5.109	3.018	4.810	3.271	22.945	14.669	25.963	55.809
	0.740	0.440	0.700	0.480	3.340	2.140	3.780	8.130

Area analysis on land use change within pine forest areas from 1981 to 1990.

Class	Land Use Change	Area (%)	Cumm (%)	Area (km sq.)
2	Pine to Forest w/ associated landuses	62.140	62.140	575.482
3	Pine to Agricultural area	3.770	65.900	34.881
4	Pine to Built-up area	0.020	65.930	0.224
5	Pine to Riverwash	0.170	66.100	1.598
6	Pine to Reservoir	0.190	66.290	1.763
8	Pine to Mines	0.260	66.550	2.420
11	Pine to Brushland/Grassland	33.450	100.000	309.790
Total of 7 classes		100.000		926.158

Legend	N17	N18	N19	N20	N21	N28	N29	N30
Forest with	4.586	0.553	1.912	0.000	0.000	30.997	2.286	0.508
Associated	0.670	0.080	0.280	0.000	0.000	4.510	0.330	0.070
Landuse	1.080	0.130	0.450	0.000	0.000	7.270	0.540	0.120
	82.750	18.500	67.720	0.000	0.000	92.220	68.300	18.890
Agriculture	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Riverwash	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Reservoir	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mines	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brushland	0.956	2.435	0.911	7.096	0.164	2.614	1.061	2.181
	0.140	0.350	0.130	1.030	0.020	0.380	0.150	0.320
	0.410	1.040	0.390	3.020	0.070	1.110	0.450	0.930
	17.250	81.500	32.280	100.000	100.000	7.780	31.700	81.110
Total	5.542	2.988	2.823	7.096	0.164	33.611	3.346	2.689
	0.810	0.440	0.410	1.030	0.020	4.900	0.490	0.390

Legend	N31	N32	N33	N34	N35	N36	Total
Forest with	3.137	6.259	9.157	3.257	11.771	13.265	426.204
Associated	0.460	0.910	1.330	0.470	1.710	1.930	62.080
Landuse	0.740	1.470	2.150	0.760	2.760	3.110	
	32.860	65.880	47.820	75.430	40.180	57.590	
Agriculture	0.000	0.000	0.000	0.000	0.194	0.000	21.063
	0.000	0.000	0.000	0.000	0.030	0.000	3.070
	0.000	0.000	0.000	0.000	0.920	0.000	
	0.000	0.000	0.000	0.000	0.660	0.000	
Riverwash	0.090	0.478	0.000	0.000	0.000	0.000	0.568
	0.010	0.070	0.000	0.000	0.000	0.000	0.080
	15.790	84.210	0.000	0.000	0.000	0.000	
	0.940	5.030	0.000	0.000	0.000	0.000	
Reservoir	0.000	0.000	0.000	0.000	0.000	0.000	1.763
	0.000	0.000	0.000	0.000	0.000	0.000	0.260
	0.000	0.000	0.000	0.000	0.000	0.000	
	0.000	0.000	0.000	0.000	0.000	0.000	
Mines	0.000	0.000	0.224	0.000	0.000	0.508	1.897
	0.000	0.000	0.030	0.000	0.000	0.070	0.280
	0.000	0.000	11.810	0.000	0.000	26.770	
	0.000	0.000	1.170	0.000	0.000	2.200	
Brushland	6.319	2.764	9.770	1.061	17.328	9.262	235.099
	0.920	0.400	1.420	0.150	2.520	1.350	34.240
	2.690	1.180	4.160	0.450	7.370	3.940	
	66.200	29.090	51.010	24.570	59.150	40.210	
Total	9.546	9.501	19.151	4.317	29.294	23.035	686.593
	1.390	1.380	2.790	0.630	4.270	3.350	

Area cross tabulation of the 1981-1990 landuse change for pine forest across the Central Plain and S sub-basins of the Agno River Basin

Area (km sq)
Total %
Row %
Col %

Legend	Central Plain	Total
Forest with Associated Landuse	7.4094 53.2200 100.0000 53.2200	7.4094 53.2200
Agriculture	0.0747 0.5400 100.0000 0.5400	0.0747 0.5400
Riverwash	1.0307 7.4000 100.0000 7.4000	1.0307 7.4000
Brushland	5.4077 38.8400 100.0000 38.8400	5.4077 38.8400
Total	13.9225 100.0000	13.9225

Area cross tabulation of the 1981-1990 landuse change for pine forest within the municipalities of Pangasinan

Area (km sq)
Total %
Row %
Col %

Municipality	Forest with Associate Landuse	Agricultural Areas	Riverwas	Brushland	Total
San Manuel	5.1686	0.0149	0.9262	6.6774	12.7872
	14.3200	0.0400	2.5700	18.5000	35.4300
	40.4200	0.1200	7.2400	52.2200	
	37.8100	20.0000	57.9400	32.1800	
San Nicolas	8.4999	0.0598	0.6722	14.0719	23.3037
	23.5500	0.1700	1.8600	38.9900	64.5700
	36.4700	0.2600	2.8800	60.3800	
	62.1900	80.0000	42.0600	67.8200	
Total	13.6685	0.0747	1.5984	20.7493	36.0909
	37.8700	0.2100	4.4300	57.4900	

Area cross tabulation of the 1981-1990 landuse change for pine forest within the municipalities of Benguet

Area (km sq)
Total %
Row %
Col %

Municipality	Forest w/ Associated Landuse	Agricultural Areas	Built-up Areas	Reservoir	Mines	Brushland	Total
Bakun	24.917	0.239	0.000	0.000	0.000	4.437	29.593
	2.780	0.030	0.000	0.000	0.000	0.490	3.300
	84.200	0.810	0.000	0.000	0.000	14.990	
	4.390	0.690	0.000	0.000	0.000	1.530	
Mankayan	24.155	4.332	0.000	0.000	0.000	13.205	41.693
	2.690	0.480	0.000	0.000	0.000	1.470	4.650
	57.940	10.390	0.000	0.000	0.000	31.670	
	4.250	12.450	0.000	0.000	0.000	4.560	
Buguias	9.501	7.544	0.000	0.000	0.000	1.165	18.210
	1.060	0.840	0.000	0.000	0.000	0.130	2.030
	52.170	41.430	0.000	0.000	0.000	6.400	
	1.670	21.670	0.000	0.000	0.000	0.400	
Kibungan	24.514	4.765	0.000	0.000	0.000	5.662	34.941
	2.730	0.530	0.000	0.000	0.000	0.630	3.900
	70.160	13.640	0.000	0.000	0.000	16.200	
	4.320	13.690	0.000	0.000	0.000	1.950	
Kabayan	43.396	0.807	0.000	0.000	0.493	8.037	52.732
	4.840	0.090	0.000	0.000	0.050	0.900	5.880
	82.290	1.530	0.000	0.000	0.930	15.240	
	7.640	2.320	0.000	0.000	20.370	2.770	
Atok	28.069	3.809	0.000	0.000	0.000	9.456	41.334
	3.130	0.420	0.000	0.000	0.000	1.050	4.610
	67.910	9.220	0.000	0.000	0.000	22.880	
	4.940	10.940	0.000	0.000	0.000	3.260	
Kapangan	0.149	0.149	0.000	0.000	0.000	11.622	11.921
	0.020	0.020	0.000	0.000	0.000	1.300	1.330
	1.250	1.250	0.000	0.000	0.000	97.490	
	0.030	0.430	0.000	0.000	0.000	4.010	
Tublay	7.783	0.329	0.000	0.000	0.000	9.202	17.313
	0.870	0.040	0.000	0.000	0.000	1.030	1.930
	44.950	1.900	0.000	0.000	0.000	53.150	
	1.370	0.940	0.000	0.000	0.000	3.170	

Municipality	Forest w/ Associated Landuse	Agricultural Areas	Built-up Areas	Reservoir	Mines	Brushland	Total
Sablan	4.168	0.000	0.000	0.000	0.000	0.090	4.257
	0.460	0.000	0.000	0.000	0.000	0.010	0.470
	97.890	0.000	0.000	0.000	0.000	2.110	
	0.730	0.000	0.000	0.000	0.000	0.030	
La Trinidad	3.869	0.493	0.224	0.000	0.612	8.754	13.952
	0.430	0.050	0.020	0.000	0.070	0.980	1.560
	27.730	3.530	1.610	0.000	4.390	62.740	
	0.680	1.420	100.000	0.000	25.310	3.020	
Tuba	48.818	0.194	0.000	0.000	0.732	40.871	90.616
	5.440	0.020	0.000	0.000	0.080	4.560	10.100
	53.870	0.210	0.000	0.000	0.810	45.100	
	8.600	0.560	0.000	0.000	30.250	14.100	
Baguio City	3.720	0.194	0.000	0.000	0.000	6.304	10.218
	0.410	0.020	0.000	0.000	0.000	0.700	1.140
	36.400	1.900	0.000	0.000	0.000	61.700	
	0.660	0.560	0.000	0.000	0.000	2.170	
Itogon	176.854	1.613	0.000	0.000	0.105	106.868	285.441
	19.720	0.180	0.000	0.000	0.010	11.910	31.820
	61.960	0.570	0.000	0.000	0.040	37.440	
	31.140	4.640	0.000	0.000	4.320	36.870	
Bokod	167.936	10.337	0.000	1.763	0.478	64.205	244.719
	18.720	1.150	0.000	0.200	0.050	7.160	27.280
	68.620	4.220	0.000	0.720	0.200	26.240	
	29.570	29.700	0.000	100.000	19.750	22.150	
Total	567.849	34.806	0.224	1.763	2.420	289.877	896.939
	63.310	3.880	0.020	0.200	0.270	32.320	

Tables on single area and area cross tabulation analysis for 1981-1990 landuse change for brushland area

Area analysis on the land use/cover change within brushland areas.

Class	Land Use Change	Area (%)	Cumm (%)	Area (km sq.)
1	Brushland to Forest	6.23	6.23	74.99
2	Brushland to Forest w/ associated landuses	21.62	27.85	260.15
3	Brushland to Agricultural area	7.29	35.14	87.79
4	Brushland to Built-up areas	0.23	35.37	2.81
5	Brushland to Riverwash	0.36	35.73	4.35
6	Brushland to Reservoir	0.01	35.75	0.13
7	Brushland to Fishpond	0.08	35.82	0.91
8	Brushland to Mines	0.22	36.04	2.69
9	Brushland to Swamps	0.02	36.06	0.19
11	Brushland to Brush/Grassland	63.94	100.00	769.55
Total of 10 classes		100.00		1,203.56

Area cross tabulation of the 1981-1990 landuse change for brushland area acroos the N sub-basins of the Agno River Basin

Area (km sq)
Total %
Row %
Col %

Legend	N1	N2	N3	N4	N5	N6	N7
Forest with	1.344	0.433	1.628	0.015	1.703	2.599	1.972
Associated	0.510	0.160	0.610	0.010	0.640	0.980	0.740
landuse	1.080	0.350	1.310	0.010	1.370	2.090	1.580
	67.670	25.660	46.380	2.380	94.210	63.970	36.160
Agriculture	0.642	1.255	1.554	0.000	0.105	0.000	1.120
	0.240	0.470	0.590	0.000	0.040	0.000	0.420
	4.090	7.990	9.900	0.000	0.670	0.000	7.140
	32.330	74.340	44.260	0.000	5.790	0.000	20.550
Riverwash	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Reservoir	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mines	0.000	0.000	0.000	0.000	0.000	0.000	1.897
	0.000	0.000	0.000	0.000	0.000	0.000	0.720
	0.000	0.000	0.000	0.000	0.000	0.000	84.110
	0.000	0.000	0.000	0.000	0.000	0.000	34.790
Brushland	0.000	0.000	0.329	0.612	0.000	1.464	0.463
	0.000	0.000	0.120	0.230	0.000	0.550	0.170
	0.000	0.000	0.270	0.500	0.000	1.200	0.380
	0.000	0.000	9.360	97.620	0.000	36.030	8.490
Total	1.987	1.688	3.510	0.627	1.808	4.063	5.452
	0.750	0.640	1.320	0.240	0.680	1.530	2.060

Legend	N8	N9	N10	N11	N12	N13	N14
Forest with	5.273	4.191	2.315	8.186	3.525	0.015	2.868
Associated	1.990	5.350	0.870	3.090	1.330	0.010	1.080
landuse	4.230	11.390	1.860	6.570	2.830	0.010	2.300
	36.020	45.637	0.520	68.240	37.460	3.330	25.160
Agriculture	2.047	5.497	0.000	0.000	0.000	0.000	0.239
	0.770	2.070	0.000	0.000	0.000	0.000	0.090
	13.040	35.010	0.000	0.000	0.000	0.000	1.520
	13.980	17.680	0.000	0.000	0.000	0.000	2.100
Riverwash	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Reservoir	0.134	0.000	0.000	0.000	0.000	0.000	0.000
	0.050	0.000	0.000	0.000	0.000	0.000	0.000
	100.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.920	0.000	0.000	0.000	0.000	0.000	0.000
Mines	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brushland	7.185	11.413	1.165	3.809	5.886	0.433	8.290
	2.710	4.310	0.440	1.440	2.220	0.160	3.130
	5.880	9.330	0.950	3.120	4.810	0.350	6.780
	49.080	36.700	33.480	31.760	62.540	96.670	72.740
Total	14.640	31.101	3.481	11.995	9.411	0.448	11.398
	5.520	11.740	1.310	4.530	3.550	0.170	4.300

Legend	N22	N26	N27	N28	N29	N30	N31
Forest with	0.000	1.793	6.767	3.421	1.150	2.226	2.300
Associated	0.000	0.680	2.550	1.290	0.430	0.840	0.870
landuse	0.000	1.440	5.430	2.750	0.920	1.790	1.850
	0.000	100.000	100.000	97.030	66.380	70.950	51.160
Agriculture	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Riverwash	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Reservoir	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mines	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brushland	0.344	0.000	0.000	0.150	0.583	0.911	2.196
	0.130	0.000	0.000	0.040	0.220	0.340	0.830
	0.280	0.000	0.000	0.090	0.480	0.750	1.800
	100.000	0.000	0.000	2.970	33.620	29.050	48.840
Total	0.344	1.793	6.767	3.525	1.733	3.137	4.496
	0.130	0.680	2.550	1.330	0.650	1.180	1.700

Legend	N15	N16	N17	N18	N19	N20	N21
Forest with	5.826	0.493	5.408	0.359	2.136	0.000	1.359
Associated	2.200	0.190	2.040	0.140	0.810	0.000	0.510
landuse	4.680	0.400	4.340	0.290	1.710	0.000	1.090
	42.390	34.020	56.470	18.900	100.000	0.000	24.200
Agriculture	0.075	0.000	0.538	0.000	0.000	0.030	0.000
	0.030	0.000	0.200	0.000	0.000	0.010	0.000
	0.480	0.000	3.430	0.000	0.000	0.190	0.000
	0.540	0.000	5.620	0.000	0.000	0.620	0.000
Riverwash	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Reservoir	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mines	0.359	0.000	0.000	0.000	0.000	0.000	0.000
	0.140	0.000	0.000	0.000	0.000	0.000	0.000
	15.890	0.000	0.000	0.000	0.000	0.000	0.000
	2.610	0.000	0.000	0.000	0.000	0.000	0.000
Brushland	17.484	0.956	3.630	0.539	0.000	4.825	4.257
	2.820	0.360	1.370	0.580	0.000	1.820	1.610
	6.120	0.780	2.970	1.260	0.000	3.950	3.480
	54.460	65.980	37.910	81.100	0.000	99.380	75.800
Total	13.743	1.449	9.575	1.897	2.136	4.855	5.617
	5.190	0.550	3.610	0.720	0.810	1.830	2.120

Legend	N32	N33	N34	N35	N36	N37	Total
Forest with	0.314	0.448	17.791	4.750	21.974	0.030	124.615
Associated	0.120	0.170	6.710	1.790	8.290	0.014	7.020
landuse	0.250	0.360	14.280	3.810	17.630	0.020	
	72.410	19.480	79.080	25.670	43.430	0.370	
Agriculture	0.000	0.000	0.179	0.000	0.000	2.420	15.700
	0.000	0.000	0.070	0.000	0.000	0.910	5.920
	0.000	0.000	1.140	0.000	0.000	15.410	
	0.000	0.000	0.800	0.000	0.000	30.220	
Riverwash	0.000	0.000	0.000	0.030	0.000	0.000	0.030
	0.000	0.000	0.010	0.000	0.000	0.000	0.010
	0.000	0.000	100.000	0.000	0.000	0.000	
	0.000	0.000	0.130	0.000	0.000	0.000	
Reservoir	0.000	0.000	0.000	0.000	0.000	0.000	0.134
	0.000	0.000	0.000	0.000	0.000	0.000	0.050
	0.000	0.000	0.000	0.000	0.000	0.000	
	0.000	0.000	0.000	0.000	0.000	0.000	
Mines	0.000	0.000	0.000	0.000	0.000	0.000	2.256
	0.000	0.000	0.000	0.000	0.000	0.000	0.850
	0.000	0.000	0.000	0.000	0.000	0.000	
	0.000	0.000	0.000	0.000	0.000	0.000	
Brushland	0.120	1.852	4.496	13.758	28.622	5.557	122.285
	0.050	0.700	1.700	5.190	10.800	2.100	46.140
	0.100	1.510	3.680	11.250	23.410	4.540	
	27.590	80.520	19.990	74.330	56.570	69.400	
Total	0.433	2.300	22.497	18.509	50.596	8.007	265.020
	0.160	0.870	8.490	6.980	19.090	3.020	

Area cross tabulation of the 1981-1990 landuse change
for brushland area across the Central Plain and S sub-basins
of the Agno River Basin

Area (km sq)
Total %
Row %
Col %

Legend	Central Plain	S1	S2	S3	S5	S6	S8
Forest	2.002	0.523	0.015	0.164	17.343	3.884	0.000
	0.810	0.210	0.010	0.070	7.040	1.580	0.000
	2.730	0.710	0.020	0.220	23.640	5.290	0.000
	2.560	5.430	0.380	2.290	87.560	11.110	0.000
Forest with	7.544	0.000	0.000	0.000	0.000	0.000	0.000
Associated	3.060	0.000	0.000	0.000	0.000	0.000	0.000
Landuse	77.570	0.000	0.000	0.000	0.000	0.000	0.000
	9.640	0.000	0.000	0.000	0.000	0.000	0.000
Agriculture	8.306	0.000	0.000	0.000	0.000	0.941	0.568
	3.370	0.000	0.000	0.000	0.000	0.380	0.230
	58.280	0.000	0.000	0.000	0.000	6.600	3.980
	10.620	0.000	0.000	0.000	0.000	2.690	29.690
Built-up	0.149	0.000	0.000	0.000	0.000	0.000	0.000
	0.060	0.000	0.000	0.000	0.000	0.000	0.000
	100.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.190	0.000	0.000	0.000	0.000	0.000	0.000
Riverwash	0.837	0.254	0.000	0.000	0.493	0.657	0.000
	0.340	0.100	0.000	0.000	0.200	0.270	0.000
	37.330	11.330	0.000	0.000	22.000	29.330	0.000
	1.070	2.640	0.000	0.000	2.490	1.880	0.000
Brushland	59.380	8.858	3.944	7.021	1.972	29.488	1.344
	24.110	3.600	1.600	2.850	0.800	11.970	0.550
	40.520	6.040	2.690	4.790	1.350	20.120	0.920
	75.920	91.940	99.620	97.710	9.950	84.320	70.310
Total	78.217	9.635	3.959	7.185	19.808	34.970	1.912
	31.760	3.910	1.610	2.920	8.040	14.200	0.780

Legend	S9	S10	S11	S12	S13	S14	S15
Forest	39.034	7.036	0.403	0.000	2.958	0.000	0.000
	15.850	2.860	0.160	0.000	1.200	0.000	0.000
	53.210	9.590	0.550	0.000	4.030	0.000	0.000
	98.600	74.060	28.720	0.000	29.120	0.000	0.000
Forest with Associated Landuse	0.000	0.000	0.000	0.000	0.000	1.105	0.015
	0.000	0.000	0.000	0.000	0.000	0.450	0.010
	0.000	0.000	0.000	0.000	0.000	11.370	0.150
	0.000	0.000	0.000	0.000	0.000	54.010	0.280
Agriculture	0.000	0.000	0.000	0.732	2.958	0.254	0.000
	0.000	0.000	0.000	0.300	1.200	0.100	0.000
	0.000	0.000	0.000	5.140	20.750	1.780	0.000
	0.000	0.000	0.000	18.850	29.120	12.410	0.000
Built-up	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Riverwash	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brushland	0.553	2.465	1.001	3.152	4.242	0.687	5.393
	0.220	1.000	0.410	1.280	1.720	0.280	2.190
	0.380	1.680	0.680	2.150	2.900	0.470	3.680
	1.400	25.940	71.280	81.150	41.760	33.580	99.720
Total	39.586	9.501	1.404	3.884	10.158	2.047	5.408
	16.070	3.860	0.570	1.580	4.120	0.830	2.200

Legend	S16	S17	S18	S19	S20	S21	S22	Total
Forest	0.000	0.000	0.000	0.000	0.000	0.000	0.000	73.362
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	29.790
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
Forest with	0.105	0.000	0.045	0.000	0.000	0.015	0.896	9.725
Associated	0.040	0.000	0.020	0.000	0.000	0.010	0.360	3.950
Landuse	1.080	0.000	0.460	0.000	0.000	0.150	9.220	
	4.430	0.000	1.480	0.000	0.000	3.230	11.520	
Agriculture	0.224	0.000	0.000	0.000	0.000	0.000	0.269	14.251
	0.090	0.000	0.000	0.000	0.000	0.000	0.110	5.790
	1.570	0.000	0.000	0.000	0.000	0.000	1.890	
	9.490	0.000	0.000	0.000	0.000	0.000	3.450	
Built-up	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.149
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.060
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
Riverwash	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.241
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.910
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
Brushland	2.032	1.942	2.988	1.001	2.017	0.448	6.618	146.544
	0.820	0.790	1.210	0.410	0.820	0.180	2.690	59.510
	1.390	1.330	2.040	0.680	1.380	0.310	4.520	
	86.080	100.000	98.520	100.000	100.000	96.770	85.030	
Total	2.360	1.942	3.032	1.001	2.017	0.463	7.783	246.272
	0.960	0.790	1.230	0.410	0.820	0.190	3.160	

Area cross tabulation of the 1981-1990 landuse change for brushland within the municipalities of Pangasinan.

Area (km sq.)
Total %
Row %
Col %

Municipality	Forest w/ Associated Landuses	Agricultural Areas	Built-up Areas	Riverwash	Fishpond	Freshwater Swamp	Brushland	Total
Labrador	3.197	0.359	0.000	0.000	0.000	0.000	7.798	11.353
	1.030	0.120	0.000	0.000	0.000	0.000	2.510	3.650
	28.160	3.160	0.000	0.000	0.000	0.000	68.680	
	8.350	0.990	0.000	0.000	0.000	0.000	3.340	
Sual	0.000	1.180	0.000	0.000	0.388	0.000	4.302	5.871
	0.000	0.380	0.000	0.000	0.130	0.000	1.390	1.890
	0.000	20.100	0.000	0.000	6.620	0.000	73.280	
	0.000	3.260	0.000	0.000	42.620	0.000	1.840	
Alaminos	0.000	1.539	0.000	0.000	0.000	0.000	1.240	2.779
	0.000	0.500	0.000	0.000	0.000	0.000	0.400	0.890
	0.000	55.380	0.000	0.000	0.000	0.000	44.620	
	0.000	4.260	0.000	0.000	0.000	0.000	0.530	
Bani	0.000	3.869	0.000	0.000	0.508	0.000	31.520	35.897
	0.000	1.250	0.000	0.000	0.160	0.000	10.150	11.560
	0.000	10.780	0.000	0.000	1.410	0.000	87.810	
	0.000	10.700	0.000	0.000	55.740	0.000	13.480	
Bolinao	0.000	4.706	0.000	0.000	0.000	0.000	22.422	27.128
	0.000	1.510	0.000	0.000	0.000	0.000	7.220	8.730
	0.000	17.350	0.000	0.000	0.000	0.000	82.650	
	0.000	13.020	0.000	0.000	0.000	0.000	9.590	
Anda	0.000	0.941	0.030	0.000	0.015	0.000	0.538	1.524
	0.000	0.300	0.010	0.000	0.000	0.000	0.170	0.490
	0.000	61.760	1.960	0.000	0.980	0.000	35.290	
	0.000	2.600	8.700	0.000	1.640	0.000	0.230	
Agno	0.000	6.394	0.000	0.120	0.000	0.045	34.731	41.289
	0.000	2.060	0.000	0.040	0.000	0.010	11.180	13.290
	0.000	15.480	0.000	0.290	0.000	0.110	84.120	
	0.000	17.690	0.000	12.120	0.000	23.080	14.860	
Burgos	0.000	2.689	0.015	0.000	0.000	0.149	12.354	15.207
	0.000	0.870	0.000	0.000	0.000	0.050	3.980	4.900
	0.000	17.680	0.100	0.000	0.000	0.980	81.240	
	0.000	7.440	4.350	0.000	0.000	76.920	5.280	

Municipality	Forest w/ Associated Landuses	Agricultural Areas	Built-up Areas	Riverwash	Fishpond	Freshwater Swamp	Brushland	Total
Mabini	0.000	0.762	0.000	0.000	0.000	0.000	14.415	15.177
	0.000	0.250	0.000	0.000	0.000	0.000	4.640	4.890
	0.000	5.020	0.000	0.000	0.000	0.000	94.980	
	0.000	2.110	0.000	0.000	0.000	0.000	6.170	
Dasol	0.000	4.765	0.149	0.000	0.000	0.000	18.075	22.990
	0.000	1.530	0.050	0.000	0.000	0.000	5.820	7.400
	0.000	20.730	0.650	0.000	0.000	0.000	78.620	
	0.000	13.180	43.480	0.000	0.000	0.000	7.730	
Infanta	2.271	0.538	0.000	0.000	0.000	0.000	7.275	10.083
	0.730	0.170	0.000	0.000	0.000	0.000	2.340	3.250
	22.520	5.330	0.000	0.000	0.000	0.000	72.150	
	5.930	1.490	0.000	0.000	0.000	0.000	3.110	
Bugallon	0.015	0.000	0.000	0.000	0.000	0.000	1.374	1.389
	0.000	0.000	0.000	0.000	0.000	0.000	0.440	0.450
	1.080	0.000	0.000	0.000	0.000	0.000	98.920	
	0.040	0.000	0.000	0.000	0.000	0.000	0.590	
Aguilar	0.045	0.000	0.000	0.000	0.000	0.000	5.467	5.512
	0.010	0.000	0.000	0.000	0.000	0.000	1.760	1.770
	0.810	0.000	0.000	0.000	0.000	0.000	99.190	
	0.120	0.000	0.000	0.000	0.000	0.000	2.340	
Mangatarem	1.210	0.807	0.000	0.000	0.000	0.000	9.321	11.338
	0.390	0.260	0.000	0.000	0.000	0.000	3.000	3.650
	10.670	7.110	0.000	0.000	0.000	0.000	82.210	
	3.160	2.230	0.000	0.000	0.000	0.000	3.990	
Sison	6.259	1.150	0.000	0.030	0.000	0.000	7.604	15.043
	2.020	0.370	0.000	0.010	0.000	0.000	2.450	4.840
	41.610	7.650	0.000	0.200	0.000	0.000	50.550	
	16.350	3.180	0.000	3.030	0.000	0.000	3.250	
Binalonan	0.000	0.000	0.000	0.000	0.000	0.000	0.881	0.881
	0.000	0.000	0.000	0.000	0.000	0.000	0.280	0.280
	0.000	0.000	0.000	0.000	0.000	0.000	100.000	
	0.000	0.000	0.000	0.000	0.000	0.000	0.380	
San Manuel	6.199	0.792	0.000	0.329	0.000	0.000	12.817	20.137
	2.000	0.250	0.000	0.110	0.000	0.000	4.130	6.480
	30.790	3.930	0.000	1.630	0.000	0.000	63.650	
	16.200	2.190	0.000	33.330	0.000	0.000	5.480	
San Nicolas	8.978	0.702	0.000	0.493	0.000	0.000	17.284	27.457
	2.890	0.230	0.000	0.160	0.000	0.000	5.560	8.840
	32.700	2.560	0.000	1.800	0.000	0.000	62.950	
	23.460	1.940	0.000	50.000	0.000	0.000	7.390	

Municipality	Forest w/ Associated Landuses	Agricultural Areas	Built-up Areas	Riverwash	Fishpond	Freshwater Swamp	Brushland	Total
Natividad	0.000	0.000	0.000	0.015	0.000	0.000	1.808	1.822
	0.000	0.000	0.000	0.000	0.000	0.000	0.580	0.590
	0.000	0.000	0.000	0.820	0.000	0.000	99.180	
	0.000	0.000	0.000	1.520	0.000	0.000	0.770	
San Quintin	4.915	0.000	0.000	0.000	0.000	0.000	2.032	6.946
	1.580	0.000	0.000	0.000	0.000	0.000	0.650	2.240
	70.750	0.000	0.000	0.000	0.000	0.000	29.250	
	12.840	0.000	0.000	0.000	0.000	0.000	0.870	
Umingan	5.184	3.914	0.000	0.000	0.000	0.000	6.379	15.476
	1.670	1.260	0.000	0.000	0.000	0.000	2.050	4.980
	33.490	25.290	0.000	0.000	0.000	0.000	41.220	
	13.540	10.830	0.000	0.000	0.000	0.000	2.730	
Balungao	0.000	0.971	0.149	0.000	0.000	0.000	13.713	14.834
	0.000	0.310	0.050	0.000	0.000	0.000	4.410	4.780
	0.000	6.550	1.010	0.000	0.000	0.000	92.450	
	0.000	2.690	43.480	0.000	0.000	0.000	5.870	
Rosales	0.000	0.075	0.000	0.000	0.000	0.000	0.418	0.493
	0.000	0.020	0.000	0.000	0.000	0.000	0.130	0.160
	0.000	15.150	0.000	0.000	0.000	0.000	84.850	
	0.000	0.210	0.000	0.000	0.000	0.000	0.180	
Total	38.272	36.151	0.344	0.986	0.911	0.194	233.769	310.626
	12.320	11.640	0.110	0.320	0.290	0.060	75.260	

Area cross tabulation of the 1981-1990 landuse change for brushland within the muncipalities of Benguet.

Area (km sq)
Total %
Row %
Col %

Municipality	Forest w/ Associated Landuses	Agricultural Areas	Built-up Areas	Reservoir	Mines	Brushland	Total
Bakun	3.600	0.075	0.000	0.000	0.000	1.613	5.288
	0.860	0.020	0.000	0.000	0.000	0.390	1.270
	68.080	1.410	0.000	0.000	0.000	30.510	
	2.440	0.320	0.000	0.000	0.000	0.660	
Mankayan	5.034	0.881	0.284	0.000	0.000	2.360	8.560
	1.200	0.210	0.070	0.000	0.000	0.560	2.050
	58.810	10.300	3.320	0.000	0.000	27.570	
	3.410	3.740	100.000	0.000	0.000	0.970	
Buguias	2.898	3.391	0.000	0.000	0.000	0.164	6.453
	0.690	0.810	0.000	0.000	0.000	0.040	1.540
	44.910	52.550	0.000	0.000	0.000	2.550	
	1.960	14.390	0.000	0.000	0.000	0.070	
Kibungan	10.830	0.269	0.000	0.000	0.000	19.898	30.997
	2.590	0.060	0.000	0.000	0.000	4.760	7.420
	34.940	0.870	0.000	0.000	0.000	64.190	
	7.330	1.140	0.000	0.000	0.000	8.170	
Kabayan	4.945	0.777	0.000	0.000	0.687	2.226	8.634
	1.180	0.190	0.000	0.000	0.160	0.530	2.070
	57.270	9.000	0.000	0.000	7.960	25.780	
	3.350	3.300	0.000	0.000	25.560	0.910	
Atok	8.515	0.657	0.000	0.000	0.538	11.966	21.675
	2.040	0.160	0.000	0.000	0.130	2.860	5.190
	39.280	3.030	0.000	0.000	2.480	55.200	
	5.760	2.790	0.000	0.000	20.000	4.910	
Kapangan	3.540	5.393	0.000	0.000	0.000	29.473	38.406
	0.850	1.290	0.000	0.000	0.000	7.050	9.190
	9.220	14.040	0.000	0.000	0.000	76.740	
	2.400	22.890	0.000	0.000	0.000	12.100	
Tublay	2.599	2.091	0.000	0.000	0.000	10.711	15.401
	0.620	0.500	0.000	0.000	0.000	2.560	3.690
	16.880	13.580	0.000	0.000	0.000	69.540	
	1.760	8.880	0.000	0.000	0.000	4.400	

Municipality	Forest w/ Associated Landuses	Agricultural Areas	Built-up Areas	Reservoir	Mines	Brushland	Total
Sablan	2.943	0.000	0.000	0.000	0.000	12.070	15.013
	0.700	0.000	0.000	0.000	0.000	2.890	3.590
	19.600	0.000	0.000	0.000	0.000	80.400	
	1.990	0.000	0.000	0.000	0.000	4.960	
La Trinidad	0.732	0.568	0.000	0.000	0.000	2.644	3.944
	0.180	0.140	0.000	0.000	0.000	0.630	0.940
	18.560	14.390	0.000	0.000	0.000	67.050	
	0.500	2.410	0.000	0.000	0.000	1.090	
Tuba	46.966	0.956	0.000	0.000	0.000	99.564	147.486
	11.240	0.230	0.000	0.000	0.000	23.820	35.290
	31.840	0.650	0.000	0.000	0.000	67.510	
	31.800	4.060	0.000	0.000	0.000	40.880	
Baguio	0.090	0.299	0.000	0.000	0.000	2.644	3.032
	0.020	0.070	0.000	0.000	0.000	0.630	0.730
	2.960	9.850	0.000	0.000	0.000	87.190	
	0.060	1.270	0.000	0.000	0.000	1.090	
Itogon	26.754	0.314	0.000	0.000	0.359	26.635	54.062
	6.400	0.080	0.000	0.000	0.090	6.370	12.940
	49.490	0.580	0.000	0.000	0.660	49.270	
	18.110	1.330	0.000	0.000	13.330	10.940	
Bokod	28.263	7.887	0.000	0.134	1.105	21.556	58.946
	6.760	1.890	0.000	0.030	0.260	5.160	14.110
	47.950	13.380	0.000	0.230	1.880	36.570	
	19.130	33.480	0.000	100.000	41.110	8.850	
Total	147.710	23.558	0.284	0.134	2.689	243.524	417.898
	35.350	5.640	0.070	0.030	0.640	58.270	

Area cross tabulation of the 1981-1990 landuse change for brushland within the municipalities of Tarlac.

Area (km sq)
Total %
Row %
Col %

Municipality	Forest	Forest w/ Associated Landuses	Agricultural Areas	Riverwash	Brushland	Total
Bamban	2.017	0.000	0.000	0.000	9.829	11.846
	1.280	0.000	0.000	0.000	6.230	7.510
	17.020	0.000	0.000	0.000	82.980	
	2.690	0.000	0.000	0.000	13.100	
Camp O'Donnel	12.220	0.000	0.000	0.254	33.193	45.666
	7.750	0.000	0.000	0.160	21.050	28.960
	26.760	0.000	0.000	0.560	72.690	
	16.290	0.000	0.000	18.090	44.240	
Tarlac	14.744	0.000	2.196	1.150	20.630	38.720
	9.350	0.000	1.390	0.730	13.080	24.560
	38.080	0.000	5.670	2.970	53.280	
	19.660	0.000	35.420	81.910	27.490	
Sta. Ignacia	0.000	0.000	1.031	0.000	1.763	2.793
	0.000	0.000	0.650	0.000	1.120	1.770
	0.000	0.000	36.900	0.000	63.100	
	0.000	0.000	16.630	0.000	2.350	
Mayantoc	46.010	0.000	0.015	0.000	6.229	52.254
	29.180	0.000	0.010	0.000	3.950	33.140
	88.050	0.000	0.030	0.000	11.920	
	61.350	0.000	0.240	0.000	8.300	
Camiling	0.000	0.000	2.166	0.000	2.569	4.735
	0.000	0.000	1.370	0.000	1.630	3.000
	0.000	0.000	45.740	0.000	54.260	
	0.000	0.000	34.940	0.000	3.420	
San Clemente	0.000	0.045	0.792	0.000	0.822	1.658
	0.000	0.030	0.500	0.000	0.520	1.050
	0.000	2.700	47.750	0.000	49.550	
	0.000	100.000	12.770	0.000	1.090	
Total	74.990	0.045	6.199	1.404	75.035	157.673
	47.560	0.030	3.930	0.890	47.590	

Area cross tabulation of the 1981-1990 landuse change for brushland within the municipalities of La Union.

Area (km sq)
Total %
Row %
Col %

Municipality	Forest w/ Associated Landuses	Agricultural Areas	Built-up Areas	Riverwash	Brushland	Total
Bangar	0.000	0.030	0.000	0.000	0.359	0.388
	0.000	0.010	0.000	0.000	0.110	0.120
	0.000	7.690	0.000	0.000	92.310	
	0.000	0.140	0.000	0.000	0.160	
Luna	0.000	0.000	0.000	0.000	1.837	1.837
	0.000	0.000	0.000	0.000	0.570	0.570
	0.000	0.000	0.000	0.000	100.000	
	0.000	0.000	0.000	0.000	0.840	
Balaoan	0.000	0.105	0.000	0.000	11.667	11.771
	0.000	0.030	0.000	0.000	3.600	3.640
	0.000	0.890	0.000	0.000	99.110	
	0.000	0.480	0.000	0.000	5.300	
Bacnotan	0.000	2.256	0.149	0.000	14.804	17.209
	0.000	0.700	0.050	0.000	4.570	5.320
	0.000	13.110	0.870	0.000	86.020	
	0.000	10.290	6.850	0.000	6.730	
San Juan	0.000	0.120	0.000	0.000	8.858	8.978
	0.000	0.040	0.000	0.000	2.740	2.770
	0.000	1.330	0.000	0.000	98.670	
	0.000	0.540	0.000	0.000	4.030	
San Fernando	0.000	2.599	0.000	0.000	17.284	19.883
	0.000	0.800	0.000	0.000	5.340	6.140
	0.000	13.070	0.000	0.000	86.930	
	0.000	11.850	0.000	0.000	7.860	
Bauang	0.000	1.195	0.060	0.000	13.340	14.595
	0.000	0.370	0.020	0.000	4.120	4.510
	0.000	8.190	0.410	0.000	91.400	
	0.000	5.450	2.740	0.000	6.060	
Caba	0.000	1.225	0.045	0.000	15.939	17.209
	0.000	0.380	0.010	0.000	4.920	5.320
	0.000	7.120	0.260	0.000	92.620	
	0.000	5.590	2.050	0.000	7.240	

Municipality	Forest w/ Associated Landuses	Agricultural Areas	Built-up Areas	Riverwash	Brushland	Total
Aringay	9.112	0.777	0.672	0.000	18.180	28.741
	2.810	0.240	0.210	0.000	5.620	8.880
	31.700	2.700	2.340	0.000	63.250	
	11.740	3.540	30.820	0.000	8.260	
Agoo	0.000	0.896	0.224	0.000	6.812	7.932
	0.000	0.280	0.070	0.000	2.100	2.450
	0.000	11.300	2.820	0.000	85.880	
	0.000	4.090	10.270	0.000	3.100	
Sto. Tomas	0.000	0.837	0.000	0.000	6.170	7.006
	0.000	0.260	0.000	0.000	1.910	2.160
	0.000	11.940	0.000	0.000	88.060	
	0.000	3.810	0.000	0.000	2.800	
Rosario	0.000	2.226	0.000	0.000	4.183	6.409
	0.000	0.690	0.000	0.000	1.290	1.980
	0.000	34.730	0.000	0.000	65.270	
	0.000	10.150	0.000	0.000	1.900	
Pugo	4.750	1.808	0.000	0.239	6.170	12.966
	1.470	0.560	0.000	0.070	1.910	4.010
	36.640	13.940	0.000	1.840	47.580	
	6.120	8.240	0.000	12.310	2.800	
Tubao	11.473	1.240	0.508	0.000	6.453	19.674
	3.540	0.380	0.160	0.000	1.990	6.080
	58.310	6.300	2.580	0.000	32.800	
	14.770	5.650	23.290	0.000	2.930	
Naguilian	0.000	2.315	0.015	0.583	20.286	23.199
	0.000	0.720	0.000	0.180	6.270	7.170
	0.000	9.980	0.060	2.510	87.440	
	0.000	10.560	0.680	30.000	9.220	
Burgos	0.000	0.015	0.000	0.000	7.439	7.454
	0.000	0.000	0.000	0.000	2.300	2.300
	0.000	0.200	0.000	0.000	99.800	
	0.000	0.070	0.000	0.000	3.380	
Bagulin	0.000	0.881	0.000	0.075	26.411	27.367
	0.000	0.270	0.000	0.020	8.160	8.450
	0.000	3.220	0.000	0.270	96.510	
	0.000	4.020	0.000	3.850	12.000	
San Gabriel	10.980	1.016	0.090	0.000	25.261	37.346
	3.390	0.310	0.030	0.000	7.800	11.540
	29.400	2.720	0.240	0.000	67.640	
	14.140	4.630	4.110	0.000	11.480	

Municipality	Forest w/ Associated Landuses	Agricultural Areas	Built-up Areas	Riverwash	Brushland	Total
Santol	32.999	0.598	0.000	0.433	7.036	41.065
	10.190	0.180	0.000	0.130	2.170	12.690
	80.360	1.460	0.000	1.050	17.130	
	42.500	2.720	0.000	22.310	3.200	
Sudipen	8.336	1.793	0.418	0.612	1.539	12.698
	2.570	0.550	0.130	0.190	0.480	3.920
	65.650	14.120	3.290	4.820	12.120	
	10.730	8.170	19.180	31.540	0.700	
Total	77.649	21.929	2.181	1.942	220.026	323.727
	23.990	6.770	0.670	0.600	67.970	

Tables on single area and area cross tabulation analysis for Gross soil loss and sediment yield

Summary of the gross soil loss and sediment yield of the Agno River Basin using the Universal Soil Loss Equation.

Class	Sub-basin	Total Gross Soil Loss (t/ha/year) (A)	Sediment Delivery Ratio (B)	Total Sediment Yield (t/ha/year) (C)	Area (%) (D)	Area (km sq.) (E)	Total Sediment Yield (t/year) (F)
1	Central Plain	43,817.25	0.26	11,392.49	52.41	4,084.24	4,652,964,293.64
6	S1	2,012.70	0.61	1,227.75	1.34	104.22	12,795,579.23
7	S2	1,030.19	0.62	638.72	0.49	37.87	2,418,824.31
8	S3	488.81	0.58	283.51	1.52	118.34	3,355,054.97
9	S4	214.05	0.54	115.59	0.53	41.02	474,137.87
10	S5	1,138.81	0.73	831.33	2.87	223.46	18,576,929.23
11	S6	1,395.77	0.64	893.29	3.42	266.20	23,779,454.34
12	S7	99.11	0.57	56.49	0.45	34.84	196,820.57
13	S8	323.33	0.52	168.13	1.48	115.71	1,945,450.74
14	S9	55.13	0.56	30.87	1.96	152.98	472,292.09
15	S10	36.68	0.77	28.24	0.39	30.62	86,481.90
16	S11	149.66	0.69	103.27	0.70	54.48	562,589.90
17	S12	20.39	0.59	12.03	1.65	128.84	154,995.81
18	S13	149.44	0.50	74.72	1.41	110.17	823,190.24
19	S14	459.45	0.66	303.24	0.47	36.99	1,121,673.66

Class	Sub-basin	Total Gross Soil Loss (t/ha/year) (A)	Sediment Delivery Ratio (B)	Total Sediment Yield (t/ha/year) (C)	Area (%) (D)	Area (km sq.) (E)	Total Sediment Yield (t/year) (F)
20	S15	1,636.57	0.33	540.07	0.68	52.93	2,858,580.45
21	S16	373.05	0.67	249.94	0.52	40.14	1,003,273.21
22	S17	158.83	0.72	114.36	0.15	11.64	133,112.25
23	S18	161.27	0.52	83.86	0.55	43.16	361,941.49
24	S19	177.80	0.45	80.01	0.70	54.49	435,974.49
25	S20	651.64	0.47	306.27	1.59	123.81	3,791,938.77
26	S21	186.54	0.60	111.92	1.29	100.62	1,126,179.29
27	S22	83.56	0.60	50.14	0.75	58.18	291,691.25
28	N1	5,143.90	0.01	51.44	0.70	54.46	280,136.79
29	N2	587.96	0.08	47.04	0.11	8.50	39,981.28
30	N3	1,851.63	0.56	1,036.91	0.56	43.69	4,530,272.02
31	N4	1,237.13	0.48	593.82	0.40	31.46	1,868,165.27
32	N5	1,218.14	0.72	877.06	0.83	64.68	5,672,829.25
33	N6	365.72	0.57	208.46	0.62	48.12	1,003,111.44
34	N7	645.09	0.35	225.78	0.61	47.64	1,075,623.07
35	N8	213.14	0.57	121.49	0.96	74.44	904,370.07
36	N9	242.11	0.59	142.84	1.29	100.28	1,432,448.66
37	N10	75.42	0.56	42.24	0.96	74.62	315,159.06
38	N11	412.52	0.72	297.01	1.83	142.57	4,234,534.30

Class	Sub-basin	Total Gross Soil Loss (t/ha/year) (A)	Sediment Delivery Ratio (B)	Total Sediment Yield (t/ha/year) (C)	Area (%) (D)	Area (km sq.) (E)	Total Sediment Yield (t/year) (F)
39	N12	999.97	0.59	589.98	1.23	95.69	5,645,540.63
40	N13	3,027.41	0.20	605.48	1.12	87.63	5,305,838.77
41	N14	640.27	0.73	467.40	1.35	105.17	4,915,615.30
42	N15	10.44	0.75	7.83	1.47	114.47	89,630.01
43	N16	82.77	0.16	13.24	0.13	10.29	13,627.25
44	N17	746.05	0.48	358.10	0.71	55.38	1,983,179.95
45	N18	118.05	0.06	7.08	0.17	13.07	9,257.48
46	N19	9.01	0.04	0.36	0.06	5.03	181.28
47	N20	1,057.17	0.48	507.44	0.36	27.90	1,415,762.06
48	N21	231.34	0.48	111.04	0.26	20.17	223,974.13
49	N22	456.09	0.55	250.85	0.26	20.03	502,451.55
50	N23	311.87	0.09	28.07	0.04	3.41	9,571.29
51	N24	61.21	0.57	34.89	0.20	15.33	53,485.91
52	N25	1,461.78	0.47	687.04	0.31	24.23	1,664,689.68
53	N26	6.62	0.49	3.24	0.27	21.36	6,928.76
54	N27	52.32	0.44	23.02	0.36	28.11	64,711.47
55	N28	118.80	0.58	68.90	0.66	51.69	356,164.78
56	N29	43.64	0.58	25.31	0.08	6.50	16,452.28
57	N30	512.43	0.58	297.21	0.13	10.22	303,748.01

Class	Sub-basin	Total Gross Soil Loss (t/ha/year) (A)	Sediment Delivery Ratio (B)	Total Sediment Yield (t/ha/year) (C)	Area (%) (D)	Area (km sq.) (E)	Total Sediment Yield (t/year) (F)
58	N31	1,012.73	0.58	587.38	0.19	14.52	852,880.70
59	N32	353.57	0.59	208.61	0.17	13.16	274,525.89
60	N33	66.19	0.73	48.32	0.40	31.42	151,817.36
61	N34	2,841.32	0.57	1,619.55	0.79	61.43	9,948,910.39
62	N35	3,426.33	0.31	1,062.16	0.97	75.57	8,026,760.50
63	N36	1,476.59	0.57	841.66	1.27	99.23	8,351,755.46
64	N37	1,802.59	0.64	1,153.66	0.85	65.97	7,610,679.19
	Total	87,739.34			100.00	7,792.40	

Note:

(C) = (A) x (B)

(F) = (C) x (E)

TOTALS OF Gross sediment yield BY AREA

Old Areas : rklscp - Unique conditions
New Areas : pmun - Municipality map of Pangasinan

Window : 00 - Universe

Class	Legend Item of New Area	Total	Area (%)	Area
1	San Fabian	2,502.82	1.48	75.26
2	Mangaldan	456.48	0.90	45.68
3	Dagupan	1,759.36	1.00	50.67
4	Calasiao	12.76	1.05	53.21
5	Binmaley	310.00	0.95	48.06
6	San Carlos	318.51	3.50	177.72
7	Lingayen	1,166.37	1.18	59.72
8	Labrador	686.62	2.24	113.64
9	Sual	3,111.83	2.86	145.23
10	Alaminos	1,954.09	3.16	160.65
11	Bani	4,312.61	4.30	218.28
12	Bolinao	3,395.52	3.20	162.60
13	Anda	4,268.82	1.46	74.11
14	Silaqui Island	133.30	0.00	0.13
15	Santiago Island	1,076.35	0.42	21.51
16	Siapar	658.09	0.04	2.02
17	Hundred Island	172.22	0.02	1.20
18	Cabalitian Island	380.73	0.03	1.69
19	Agno	3,663.04	2.73	138.63
20	Burgos	4,328.13	2.42	123.09
21	Mabini	2,502.90	4.47	226.82
22	Dasol	5,987.99	3.36	170.40
23	Infanta	4,395.63	4.61	233.87
24	Bugallon	1,194.24	3.06	155.55
25	Aguilar	560.56	2.85	144.59
26	Mangatarem	5,568.54	5.64	286.61
27	Urbiztondo	267.85	1.06	53.96
28	Basista	30.02	0.59	29.89
29	Malasiqui	175.54	2.35	119.22
30	Sta. Barbara	43.04	1.37	69.40

Class	Legend Item of New Area	Total	Area (%)	Area
31	Mapandan	195.71	0.43	21.94
32	San Jacinto	60.77	0.60	30.32
33	Manaoag	784.77	0.90	45.91
34	Laoac	938.64	0.62	31.24
35	Pozorrubio	1,912.79	1.57	79.64
36	Sison	4,759.87	2.21	112.02
37	Binalonan	1,294.65	1.28	65.00
38	Urdaneta	14.09	2.53	128.30
39	Asingan	513.77	1.47	74.60
40	San Manuel	5,247.02	2.28	115.94
41	San Nicolas	3,773.36	4.33	219.92
42	Tayug	2.19	0.86	43.44
43	Natividad	1,291.05	1.69	85.75
44	San Quintin	1,504.00	2.25	114.19
45	Sta. Maria	55.51	0.96	48.71
46	Umingan	1,481.49	5.08	257.76
47	Balungao	114.30	1.51	76.63
48	Rosales	72.50	1.30	65.86
49	Villasis	267.06	1.55	78.58
50	Sto. Tomas	270.60	0.25	12.79
51	Alcala	2,179.24	0.89	44.96
52	Bautista	569.12	1.34	68.15
53	Bayambang	1,202.52	1.83	93.10
	Total	83,898.96	100.00	5,078.15

TOTALS OF Gross sediment yield BY AREA

Old Areas : rklscp - Unique conditions
New Areas : bmun - Municipalities of Benguet

Window : 00 - Universe

Class	Legend Item of New Area	Total	Area (%)	Area
1	Bakun	1,267.77	6.05	165.78
2	Mankayan	8,334.69	8.57	234.75
3	Buguias	4,253.01	4.44	121.54
4	Kibungan	1,841.43	5.93	162.35
5	Kabayan	1,253.01	5.78	158.29
6	Atok	2,762.53	5.07	138.85
7	Kapangan	2,647.68	5.34	146.19
8	Tublay	4,815.46	3.49	95.63
9	Sablan	2,282.19	3.86	105.67
10	La Trinidad	6,924.42	2.86	78.26
11	Tuba	5,744.49	12.80	350.50
12	Baguio City	2,178.99	2.09	57.15
13	Itogon	4,236.44	20.25	554.58
14	Bokod	7,231.12	13.48	369.05
	Total	55,773.24	100.00	2,738.60

TOTALS OF Gross sediment yield BY AREA

Old Areas : rklscp - Unique conditions
New Areas : tmun - Municipality map of Tarlac

Window : 00 - Universe

Class	Legend Item of New Area	Total	Area (%)	Area
1	Bamban	7,648.48	4.73	145.14
2	Concepcion	2,177.08	6.98	214.32
3	O'Donnel	7,107.90	16.75	514.38
4	Tarlac	6,015.38	24.66	757.28
5	La Paz	185.24	4.01	123.14
6	Victoria	37.07	3.96	121.52
7	Pura	430.85	1.07	32.74
8	Gerona	563.05	3.88	119.24
9	Santa Ignacia	526.74	3.83	117.73
10	Mayantoc	1,630.85	11.37	349.20
11	Camiling	972.30	5.98	183.52
12	Paniqui	468.10	3.07	94.14
13	Ramos	23.04	1.03	31.67
14	Nampicuan	1.03	0.83	25.37
15	Moncada	134.94	3.91	119.95
16	San Manuel	1.61	1.63	50.01
17	San Clemente	662.09	2.32	71.17
	Total	28,585.74	100.00	3,070.52

TOTALS OF Gross sediment yield BY AREA

Old Areas : rklscp - Unique conditions
New Areas : lmun - Municipality map of La Union

Window : 00 - Universe

Class	Legend Item of New Area	Total	Area (%	Area
1	Bangar	561.35	2.88	41.42
2	Luna	3,371.80	2.81	40.44
3	Balaoan	2,056.54	4.87	69.90
4	Bacnotan	3,479.11	4.54	65.19
5	San Juan	3,445.05	4.19	60.25
6	San Fernando	1,543.04	6.88	98.80
7	Bauang	3,267.62	5.28	75.83
8	Caba	1,413.73	3.44	49.46
9	Aringay	2,493.89	6.85	98.44
10	Agoo	8,091.64	2.72	39.12
11	Sto. Tomas	3,238.12	4.31	61.86
12	Rosario	2,578.64	4.82	69.24
13	Pugo	1,340.35	3.03	43.57
14	Tubao	4,137.36	3.96	56.84
15	Naguilian	4,525.29	6.61	94.98
16	Burgos	781.68	4.38	62.98
17	Bagulin	755.74	4.93	70.85
18	San Gabriel	1,169.96	10.84	155.67
19	Santol	1,793.59	7.85	112.83
20	Sudipen	2,000.93	4.80	68.91
	Total	52,045.41	100.00	1,436.58

Area cross tabulation of the slope map for Benguet, La Union, Pangasinan and Tarlac against total gross soil loss range (t/ha/year).

Area (km sq)
Total %
Row %
Col %

Slope	<100	100-200	200-300	300-400	400-500	500-600	>600	Total
0-3%	4,854.00	0.40	0.70	5.30	0.10	1.90	1.10	4,863.50
	39.75	0.00	0.01	0.04	0.00	0.02	0.01	39.83
	99.80	0.01	0.02	0.11	0.00	0.04	0.02	
	49.62	0.09	0.18	1.12	0.03	1.75	0.21	
3-8%	460.20	1.00	0.00	0.00	0.00	0.00	0.10	461.30
	3.77	0.01	0.00	0.00	0.00	0.00	0.00	3.78
	99.75	0.22	0.00	0.00	0.00	0.00	0.03	
	4.70	0.24	0.00	0.00	0.00	0.00	0.02	
8-15%	430.20	145.60	116.30	0.60	0.00	0.00	0.00	692.80
	3.52	1.19	0.95	0.01	0.00	0.00	0.00	5.67
	62.10	21.02	16.79	0.09	0.00	0.00	0.00	
	4.40	34.12	28.19	0.13	0.00	0.00	0.00	
15-25%	471.20	191.90	145.40	247.30	33.10	7.90	1.40	1,098.20
	3.86	1.57	1.19	2.03	0.27	0.06	0.01	8.99
	42.90	17.48	13.24	22.52	3.01	0.72	0.13	
	4.82	44.97	35.23	52.46	6.93	7.51	0.26	
25-40%	875.90	75.40	128.60	204.00	315.30	39.50	147.40	1,786.00
	7.17	0.62	1.05	1.67	2.58	0.32	1.21	14.63
	49.04	4.22	7.20	11.42	17.65	2.21	8.25	
	8.96	17.66	31.15	43.26	66.11	37.40	27.46	
40-60%	497.80	12.50	21.40	14.20	128.40	56.40	386.10	1,116.70
	4.08	0.10	0.18	0.12	1.05	0.46	3.16	9.14
	44.57	1.12	1.92	1.27	11.50	5.05	34.58	
	5.09	2.92	5.19	3.01	26.93	53.34	71.95	
>60%	2,188.30	0.00	0.30	0.10	0.00	0.00	0.60	2,189.30
	17.92	0.00	0.00	0.00	0.00	0.00	0.00	17.93
	99.95	0.00	0.01	0.01	0.00	0.00	0.03	
	22.37	0.00	0.06	0.03	0.01	0.00	0.11	
Reservoir	3.80	0.00	0.00	0.00	0.00	0.00	0.00	3.80
	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.03
	100.00	0.00	0.00	0.00	0.00	0.00	0.00	
	0.04	0.00	0.00	0.00	0.00	0.00	0.00	
Total	9,781.30	426.80	412.70	471.50	476.90	105.70	536.70	12,211.60
	80.10	3.50	3.38	3.86	3.91	0.87	4.39	

Are cross tabulation of the 1990 land use map of Benguet, La Union, Pangasinan and Tarlac against gross soil loss range (t/ha/year).

Area (km sq)
Total %
Row %
Col%

Land Use	<100	100-200	200-300	300-400	400-500	500-600	>600	Total
Forest	570.20	0.00	0.00	0.00	0.00	0.00	0.00	570.20
	4.67	0.00	0.00	0.00	0.00	0.00	0.00	4.67
	100.00	0.00	0.00	0.00	0.00	0.00	0.00	
	5.84	0.00	0.00	0.00	0.00	0.00	0.00	
Forest with	1,693.30	0.00	0.00	0.00	0.00	0.00	0.00	1,693.30
associated landuses	13.88	0.00	0.00	0.00	0.00	0.00	0.00	13.88
	100.00	0.00	0.00	0.00	0.00	0.00	0.00	
	17.33	0.00	0.00	0.00	0.00	0.00	0.00	
Grassland (>90%	574.70	0.00	0.00	0.00	0.00	0.00	0.00	574.70
dominant	4.71	0.00	0.00	0.00	0.00	0.00	0.00	4.71
	100.00	0.00	0.00	0.00	0.00	0.00	0.00	
	5.88	0.00	0.00	0.00	0.00	0.00	0.00	
Mangroves/nipa	28.20	0.20	0.00	0.00	0.00	0.00	0.00	28.30
	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.23
	99.42	0.58	0.00	0.00	0.00	0.00	0.00	
	0.29	0.04	0.00	0.00	0.00	0.00	0.00	
Ricefield, irrigated	3,349.20	121.00	51.00	9.60	2.40	8.30	0.90	3,542.40
	27.46	0.99	0.42	0.08	0.02	0.07	0.01	29.04
	94.55	3.41	1.44	0.27	0.07	0.23	0.03	
	34.29	28.34	12.36	2.03	0.50	7.83	0.18	
Grassland (70-90%	822.60	99.20	76.80	17.40	70.90	20.10	151.60	1,258.60
dominant	6.74	0.81	0.63	0.14	0.58	0.16	1.24	10.32
	65.36	7.88	6.11	1.38	5.63	1.59	12.05	
	8.42	23.24	18.62	3.69	14.86	18.99	28.25	
Shrubs	555.90	84.00	95.40	60.60	184.80	49.60	81.20	1,111.50
	4.56	0.69	0.78	0.50	1.51	0.41	0.67	9.11
	50.02	7.56	8.58	5.45	16.62	4.46	7.30	
	5.69	19.69	23.10	12.86	38.75	46.97	15.13	
Coconut	127.20	5.00	0.30	0.00	0.00	0.00	0.00	132.50
	1.04	0.04	0.00	0.00	0.00	0.00	0.00	1.09
	96.03	3.78	0.19	0.00	0.00	0.00	0.00	
	1.30	1.17	0.06	0.00	0.00	0.00	0.00	

Land Use	<100	100-200	200-300	300-400	400-500	500-600	>600	Total
Built-up areas	402.50	8.30	5.10	3.30	2.20	0.60	1.00	423.00
	3.30	0.07	0.04	0.03	0.02	0.00	0.01	3.47
	95.14	1.97	1.21	0.78	0.51	0.14	0.25	
	4.12	1.95	1.25	0.70	0.45	0.57	0.19	
Coffee, citrus, lanzones	2.30	0.00	0.00	0.00	0.00	0.00	0.00	2.30
	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.02
	100.00	0.00	0.00	0.00	0.00	0.00	0.00	
	0.02	0.00	0.00	0.00	0.00	0.00	0.00	
Cassava, potatoes, black pepper	79.90	0.20	0.90	1.10	0.00	0.00	1.80	83.90
	0.66	0.00	0.01	0.01	0.00	0.00	0.01	0.69
	95.30	0.21	1.02	1.34	0.00	0.00	2.14	
	0.82	0.04	0.21	0.24	0.00	0.00	0.33	
Sugar cane	337.70	4.60	0.20	0.20	0.50	1.10	0.00	344.20
	2.77	0.04	0.00	0.00	0.00	0.01	0.00	2.82
	98.10	1.34	0.06	0.05	0.14	0.31	0.00	
	3.46	1.08	0.05	0.03	0.10	1.02	0.00	
Grass (<70% dominant)	682.90	66.10	165.00	342.90	197.40	22.90	245.20	1,722.30
	5.60	0.54	1.35	2.81	1.62	0.19	2.01	14.12
	39.65	3.84	9.58	19.91	11.46	1.33	14.24	
	6.99	15.48	39.98	72.71	41.39	21.69	45.69	
Corn (>70% dominant)	13.00	0.30	3.60	0.50	0.00	0.00	0.00	17.40
	0.11	0.00	0.03	0.00	0.00	0.00	0.00	0.14
	75.04	1.72	20.48	2.75	0.00	0.00	0.00	
	0.13	0.07	0.86	0.10	0.00	0.00	0.00	
Fishponds	145.10	0.90	0.00	0.00	0.00	0.00	0.00	146.00
	1.19	0.01	0.00	0.00	0.00	0.00	0.00	1.20
	99.40	0.60	0.00	0.00	0.00	0.00	0.00	
	1.49	0.21	0.00	0.00	0.00	0.00	0.00	
Bamboo	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.80
	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	96.43	0.00	0.00	0.00	3.57	0.00	0.00	
	0.01	0.00	0.00	0.00	0.01	0.00	0.00	
Ricefield, upland	3.80	0.80	0.00	0.30	2.30	0.00	0.00	7.20
	0.03	0.01	0.00	0.00	0.02	0.00	0.00	0.06
	52.17	11.59	0.00	4.55	31.68	0.00	0.00	
	0.04	0.20	0.00	0.07	0.48	0.00	0.00	

Land Use	<100	100-200	200-300	300-400	400-500	500-600	>600	Total
Saltbeds	7.60	0.10	0.00	0.00	0.00	0.00	0.00	7.70
	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.06
	98.84	1.16	0.00	0.00	0.00	0.00	0.00	
	0.08	0.02	0.00	0.00	0.00	0.00	0.00	
Beach sand	0.10	0.20	0.70	5.30	0.10	1.90	1.30	9.50
	0.00	0.00	0.01	0.04	0.00	0.02	0.01	0.08
	0.63	1.89	7.72	55.59	1.26	19.53	13.39	
	0.00	0.04	0.18	1.12	0.03	1.75	0.24	
Ipil-ipil	0.70	0.60	0.10	0.00	0.00	0.00	0.00	1.30
	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	51.14	44.32	4.55	0.00	0.00	0.00	0.00	
	0.01	0.14	0.01	0.00	0.00	0.00	0.00	
Riverwash	192.00	11.70	4.00	3.00	1.10	0.00	0.00	211.80
	1.57	0.10	0.03	0.02	0.01	0.00	0.00	1.74
	90.65	5.53	1.89	1.42	0.51	0.00	0.00	
	1.97	2.74	0.97	0.64	0.23	0.00	0.00	
Rice terraces	55.70	14.60	2.00	22.40	3.20	0.30	6.30	104.60
	0.46	0.12	0.02	0.18	0.03	0.00	0.05	0.86
	53.22	13.98	1.96	21.42	3.03	0.33	6.07	
	0.57	3.43	0.50	4.75	0.66	0.33	1.18	
Vegetables terraces	76.80	4.20	6.50	4.50	11.50	0.90	47.30	151.70
	0.63	0.03	0.05	0.04	0.09	0.01	0.39	1.24
	50.66	2.74	4.30	2.94	7.57	0.60	31.17	
	0.79	0.97	1.58	0.95	2.41	0.86	8.81	
Mines	5.90	2.90	0.20	0.00	0.00	0.00	0.00	8.90
	0.05	0.02	0.00	0.00	0.00	0.00	0.00	0.07
	66.11	31.89	2.00	0.00	0.00	0.00	0.00	
	0.06	0.67	0.04	0.00	0.00	0.00	0.00	
Filling ponds	0.80	0.10	0.00	0.00	0.00	0.00	0.00	0.90
	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	88.52	11.48	0.00	0.00	0.00	0.00	0.00	
	0.01	0.02	0.00	0.00	0.00	0.00	0.00	
Reservoirs	6.60	0.00	0.00	0.00	0.00	0.00	0.00	6.60
	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.05
	100.00	0.00	0.00	0.00	0.00	0.00	0.00	
	0.07	0.00	0.00	0.00	0.00	0.00	0.00	

Land Use	<100	100-200	200-300	300-400	400-500	500-600	>600	Total
Grapes	0.00	0.00	0.50	0.40	0.00	0.00	0.00	0.90
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	0.00	0.00	51.61	48.39	0.00	0.00	0.00	
	0.00	0.00	0.12	0.10	0.00	0.00	0.00	
Mangoes	4.40	0.00	0.10	0.00	0.60	0.00	0.00	5.10
	0.04	0.00	0.00	0.00	0.01	0.00	0.00	0.04
	85.63	0.00	1.76	0.00	12.61	0.00	0.00	
	0.04	0.00	0.02	0.00	0.13	0.00	0.00	
Maguey	1.90	1.60	0.00	0.00	0.00	0.00	0.00	3.50
	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.03
	54.47	45.53	0.00	0.00	0.00	0.00	0.00	
	0.02	0.37	0.00	0.00	0.00	0.00	0.00	
Freshwater swamps	15.20	0.00	0.00	0.00	0.00	0.00	0.00	15.20
	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.12
	99.71	0.00	0.00	0.29	0.00	0.00	0.00	
	0.16	0.00	0.00	0.01	0.00	0.00	0.00	
Kaingin	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.50
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	100.00	0.00	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Vegetable, lowland	10.90	0.40	0.40	0.00	0.00	0.00	0.00	11.60
	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.10
	93.58	3.21	3.21	0.00	0.00	0.00	0.00	
	0.11	0.09	0.09	0.00	0.00	0.00	0.00	
Airport	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.30
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	100.00	0.00	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Total	9,768.50	426.80	412.70	471.50	476.90	105.70	536.70	12,198.80
	80.08	3.50	3.38	3.87	3.91	0.87	4.40	

Area cross tabulation for the erosion map of Benguet, La Union, Pangasinan and Tarlac against gross soil loss (t/sq.km/year) range.

Area (km sq)
Total %
Row %
Col %

Erosion Cateogry	<100	100-200	200-300	300-400	400-500	500-60	>600	Total
No erosion	4,679.90	90.00	58.10	59.80	33.90	19.10	42.10	4,982.90
	38.33	0.74	0.48	0.49	0.28	0.16	0.34	40.81
	93.92	1.81	1.17	1.20	0.68	0.38	0.84	
	47.85	21.08	14.07	12.69	7.10	18.10	7.84	
None to slight erosion	715.40	20.40	21.20	10.20	18.80	0.90	55.80	842.70
	5.86	0.17	0.17	0.08	0.15	0.01	0.46	6.90
	84.90	2.42	2.51	1.21	2.23	0.11	6.62	
	7.32	4.77	5.13	2.17	3.94	0.86	10.39	
Slight erosion	1,379.50	94.00	64.50	54.50	47.20	13.80	78.90	1,732.40
	11.30	0.77	0.53	0.45	0.39	0.11	0.65	14.19
	79.63	5.42	3.73	3.14	2.72	0.80	4.56	
	14.11	22.02	15.64	11.55	9.89	13.11	14.70	
Moderate erosion	1,841.80	154.40	182.70	190.00	168.70	52.00	105.00	2,694.50
	15.08	1.26	1.50	1.56	1.38	0.43	0.86	22.07
	68.35	5.73	6.78	7.05	6.26	1.93	3.90	
	18.83	36.18	44.26	40.30	35.37	49.20	19.56	
Severe erosion	988.40	58.50	75.10	121.30	207.30	16.50	241.10	1,708.20
	8.09	0.48	0.62	0.99	1.70	0.14	1.97	13.99
	57.86	3.43	4.40	7.10	12.14	0.97	14.12	
	10.11	13.71	18.20	25.72	43.47	15.61	44.93	
Very severe erosion	132.30	8.70	10.90	35.60	1.10	3.30	13.80	205.70
	1.08	0.07	0.09	0.29	0.01	0.03	0.11	1.68
	64.31	4.25	5.31	17.29	0.53	1.60	6.71	
	1.35	2.05	2.65	7.54	0.23	3.12	2.57	
Reservoirs	42.70	0.80	0.20	0.10	0.00	0.00	0.00	43.90
	0.35	0.01	0.00	0.00	0.00	0.00	0.00	0.36
	97.38	1.87	0.51	0.24	0.00	0.00	0.00	
	0.44	0.19	0.05	0.02	0.00	0.00	0.00	
Total	9,780.00	426.80	412.70	471.50	476.90	105.70	536.70	12,210.30
	80.10	3.50	3.38	3.86	3.91	0.87	4.40	

Tables on single area and area cross tabulation analysis for non point pollution sources

SINGLE MAP ANALYSIS

Map : critic1 - Critical areas of non point sources

Window : 00 - Universe

Class	Legend	Area (%)	Cumm	Area (km.sq.)
1	Not critical	96.57	96.57	11,794.70
2	Sub-critical	2.52	99.08	307.40
3	Critical	0.92	100.00	111.90
Total of 3 classes		100.00		12,214.10

Area cross tabulation of the critical areas for nonpoint pollution sources
sources with slope-elevation map of Benguet, La Union, Pangasinan and Tarlac.

Area (km sq)
Total %
Row %
Col %

Slope-Elevation	Critical	Sub-critical	Not Critical
0-15% at 0-5 m	0.00	2.40	754.40
	0.00	0.02	6.20
	0.00	0.32	99.68
	0.00	0.80	6.42
0-15% at 5-50 m	0.00	5.30	2,727.40
	0.00	0.04	22.42
	0.00	0.19	99.81
	0.00	1.72	23.22
0-8% at 50-800 m	0.00	0.00	1,822.00
	0.00	0.00	14.98
	0.00	0.00	100.00
	0.00	0.00	15.51
0-8% at >=800 m	0.00	0.00	78.90
	0.00	0.00	0.65
	0.00	0.00	100.00
	0.00	0.00	0.67
8-15% at 50-800 m	0.00	15.00	497.40
	0.00	0.12	4.09
	0.00	2.92	97.08
	0.00	4.86	4.23
8-15% at >=800 m	0.00	0.40	85.20
	0.00	0.00	0.70
	0.00	0.45	99.55
	0.00	0.13	0.73
15-25% at 0-50 m	4.60	16.00	125.30
	0.04	0.13	1.03
	3.16	10.97	85.87
	4.12	5.21	1.07

Slope-Elevation	Critical	Sub-critical	Not Critical
15-25% at 50-800 m	3.90	50.30	661.40
	0.03	0.41	5.44
	0.55	7.02	92.42
	3.52	16.35	5.63
15-25% at >=800 m	0.00	2.40	222.50
	0.00	0.02	1.83
	0.00	1.07	98.93
	0.00	0.78	1.89
25-40% at 0-5 m	2.10	1.90	55.50
	0.02	0.02	0.46
	3.51	3.14	93.35
	1.87	0.61	0.47
25-40% at 5-50 m	7.60	9.50	140.90
	0.06	0.08	1.16
	4.84	5.99	89.17
	6.83	3.08	1.20
25-40% at 50-800 m	35.20	83.60	1,084.30
	0.29	0.69	8.91
	2.93	6.95	90.13
	31.45	27.18	9.23
25-40% at >=800 m	3.80	14.40	345.50
	0.03	0.12	2.84
	1.04	3.95	95.01
	3.39	4.67	2.94
>40% at 0-5 m	0.20	0.50	2.00
	0.00	0.00	0.02
	6.32	17.82	75.86
	0.15	0.15	0.02
>40% at 5-50 m	0.90	1.40	7.00
	0.01	0.01	0.06
	9.66	14.98	75.36
	0.80	0.45	0.06
>40% at 50-800 m	37.90	69.20	1,150.90
	0.31	0.57	9.46
	3.01	5.50	91.49
	33.81	22.52	9.80

Slope-Elevation	Critical	Sub-critical	Not Critical
>40% at >=800 m	15.70	35.30	1,984.80
	0.13	0.29	16.32
	0.77	1.73	97.49
	14.05	11.49	16.90
Total	111.90	307.40	11,745.30
	0.92	2.53	96.55

Area cross tabulation of the critical areas for nonpoint pollution sources with the slope map of Benguet, La Union, Pangasinan and Tarlac.

Area (km sq.)
Total %
Row %
Col %

Slope	Critical	Sub-critical	Not Critical	Total
0-3%	0.00	0.00	4,863.50	4,863.50
	0.00	0.00	39.83	39.83
	0.00	0.00	100.00	
	0.00	0.00	41.24	
3-8%	0.00	0.00	461.30	461.30
	0.00	0.00	3.78	3.78
	0.00	0.00	100.00	
	0.00	0.00	3.91	
8-15%	0.00	23.10	669.70	692.80
	0.00	0.19	5.48	5.67
	0.00	3.33	96.67	
	0.00	7.51	5.68	
15-25%	8.60	68.70	1,021.00	1,098.20
	0.07	0.56	8.36	8.99
	0.78	6.25	92.97	
	7.65	22.34	8.66	
25-40%	48.70	109.30	1,628.00	1,786.00
	0.40	0.89	13.33	14.63
	2.73	6.12	91.15	
	43.54	35.54	13.81	
40-60%	54.60	106.40	955.70	1,116.70
	0.45	0.87	7.83	9.14
	4.89	9.53	85.58	
	48.81	34.61	8.10	
>60%	0.00	0.00	2,189.30	2,189.30
	0.00	0.00	17.93	17.93
	0.00	0.00	100.00	
	0.00	0.00	18.57	

Slope	Critical	Sub-critical	Not Critical	Total
Reservoir	0.00	0.00	3.80	3.80
	0.00	0.00	0.03	0.03
	0.00	0.00	100.00	
	0.00	0.00	0.03	
Total	111.90	307.40	11,792.30	12,211.60
	0.92	2.52	96.57	

Area cross tabulation of the 1990 land use map across critical areas for nonpoint pollution sources for Benguet, La Union, Pangasinan and Tarlac.

Area (km sq.)
Total %
Row %
Col %

Land use	Critical	Sub-critical	Not Critical	Total
Forest	0.00	0.00	570.20	570.20
	0.00	0.00	4.67	4.67
	0.00	0.00	100.00	
	0.00	0.00	4.84	
Forest with associated land uses	0.00	0.00	1,693.30	1,693.30
	0.00	0.00	13.88	13.88
	0.00	0.00	100.00	
	0.00	0.00	14.37	
Grasslands (>90% dominant)	0.00	0.00	574.70	574.70
	0.00	0.00	4.71	4.71
	0.00	0.00	100.00	
	0.00	0.00	4.88	
Mangrove/nipa	0.00	0.00	28.30	28.30
	0.00	0.00	0.23	0.23
	0.00	0.00	100.00	
	0.00	0.00	0.24	
Ricefield, irrigated	19.60	27.40	3,495.30	3,542.40
	0.16	0.22	28.65	29.04
	0.55	0.77	98.67	
	17.55	8.92	29.67	
Grassland (90 -70% dominant)	15.10	56.80	1,186.70	1,258.60
	0.12	0.47	9.73	10.32
	1.20	4.51	94.29	
	13.45	18.48	10.07	
Shrubs	3.30	61.90	1,046.30	1,111.50
	0.03	0.51	8.58	9.11
	0.30	5.57	94.14	
	2.96	20.13	8.88	

Land use	Critical	Sub-critical	Not Critical	Total
Coconut	0.30	0.30	131.90	132.50
	0.00	0.00	1.08	1.09
	0.19	0.26	99.55	
	0.23	0.11	1.12	
Built-up Areas	2.20	3.30	417.50	423.00
	0.02	0.03	3.42	3.47
	0.52	0.79	98.70	
	1.95	1.08	3.54	
Coffee, citrus, lanzones	0.00	0.00	2.30	2.30
	0.00	0.00	0.02	0.02
	0.00	0.00	100.00	
	0.00	0.00	0.02	
Cassava, potatoes, black pepper	0.70	0.60	82.60	83.90
	0.01	0.00	0.68	0.69
	0.86	0.66	98.49	
	0.64	0.18	0.70	
Sugar cane	0.00	0.70	343.50	344.20
	0.00	0.01	2.82	2.82
	0.00	0.21	99.79	
	0.00	0.24	2.92	
Grassland (<70% dominant)	61.40	139.70	1,521.20	1,722.30
	0.50	1.15	12.47	14.12
	3.56	8.11	88.32	
	54.83	45.45	12.91	
Corn (>70% dominant)	1.30	1.20	14.90	17.40
	0.01	0.01	0.12	0.14
	7.31	6.71	85.97	
	1.13	0.38	0.13	
Fishponds	0.00	0.10	145.90	146.00
	0.00	0.00	1.20	1.20
	0.00	0.05	99.95	
	0.00	0.02	1.24	
Bamboos	0.00	0.00	0.80	0.80
	0.00	0.00	0.01	0.01
	0.00	0.00	100.00	
	0.00	0.00	0.01	

Land use	Critical	Sub-critical	Not Critical	Total
Ricefield, upland	0.00	0.00	7.20	7.20
	0.00	0.00	0.06	0.06
	0.00	0.00	100.00	
	0.00	0.00	0.06	
Saltbeds	0.00	0.00	7.70	7.70
	0.00	0.00	0.06	0.06
	0.00	0.00	100.00	
	0.00	0.00	0.07	
Beach sands	0.00	0.00	9.50	9.50
	0.00	0.00	0.08	0.08
	0.00	0.00	100.00	
	0.00	0.00	0.08	
Ipil-ipil	0.00	0.00	1.30	1.30
	0.00	0.00	0.01	0.01
	0.00	0.00	100.00	
	0.00	0.00	0.01	
Riverwash	0.20	1.40	210.20	211.80
	0.00	0.01	1.72	1.74
	0.08	0.68	99.24	
	0.16	0.47	1.78	
Rice terraces	0.00	0.40	104.20	104.60
	0.00	0.00	0.85	0.86
	0.00	0.43	99.57	
	0.00	0.15	0.88	
Vegetable terraces	7.80	12.00	131.80	151.70
	0.06	0.10	1.08	1.24
	5.17	7.90	86.93	
	7.01	3.90	1.12	
Mines	0.00	0.90	8.00	8.90
	0.00	0.01	0.07	0.07
	0.00	10.35	89.65	
	0.00	0.30	0.07	
Filling ponds	0.00	0.00	0.90	0.90
	0.00	0.00	0.01	0.01
	0.00	0.00	100.00	
	0.00	0.00	0.01	

Land use	Critical	Sub-critical	Not Critical	Total
Reservoirs	0.00	0.00	6.60	6.60
	0.00	0.00	0.05	0.05
	0.00	0.00	100.00	
	0.00	0.00	0.06	
Grapes	0.00	0.00	0.90	0.90
	0.00	0.00	0.01	0.01
	0.00	0.00	100.00	
	0.00	0.00	0.01	
Mango	0.00	0.50	4.60	5.10
	0.00	0.00	0.04	0.04
	0.00	9.68	90.32	
	0.00	0.16	0.04	
Maguey	0.10	0.00	3.40	3.50
	0.00	0.00	0.03	0.03
	2.98	0.00	97.02	
	0.09	0.00	0.03	
Freshwater swamp	0.00	0.00	15.20	15.20
	0.00	0.00	0.12	0.12
	0.00	0.00	100.00	
	0.00	0.00	0.13	
Kaingin	0.00	0.00	0.50	0.50
	0.00	0.00	0.00	0.00
	0.00	0.00	100.00	
	0.00	0.00	0.00	
Vegetable, lowland	0.00	0.10	11.50	11.60
	0.00	0.00	0.09	0.10
	0.00	1.03	98.97	
	0.00	0.04	0.10	
Airport	0.00	0.00	0.30	0.30
	0.00	0.00	0.00	0.00
	0.00	0.00	100.00	
	0.00	0.00	0.00	
Total	111.90	307.40	11,779.50	12,198.80
	0.92	2.52	96.56	

Area cross tabulation of critical areas for nonpollution sources with the elevation map of Benguet, La Union, Pangasinan and Tarlac.

Area (km sq.)
Total %
Row %
Col %

Elevation	Critical	Sub-critical	Not Critical	Total
<1 m	2.10	10.80	757.70	770.60
	0.02	0.09	6.23	6.33
	0.27	1.41	98.32	
	1.88	3.53	6.45	
1-3 m	0.30	0.70	40.50	41.40
	0.00	0.01	0.33	0.34
	0.61	1.73	97.66	
	0.23	0.23	0.34	
3-5 m	0.50	0.50	46.90	47.80
	0.00	0.00	0.39	0.39
	1.00	1.00	98.00	
	0.43	0.16	0.40	
5-10 m	0.80	1.80	156.20	158.80
	0.01	0.01	1.28	1.31
	0.52	1.14	98.34	
	0.73	0.59	1.33	
10-50 m	11.80	23.10	2,812.40	2,847.20
	0.10	0.19	23.11	23.39
	0.41	0.81	98.78	
	10.50	7.51	23.93	
50-75 m	4.90	14.50	824.00	843.40
	0.04	0.12	6.77	6.93
	0.58	1.71	97.71	
	4.35	4.70	7.01	
75-100 m	4.50	16.40	567.20	588.10
	0.04	0.14	4.66	4.83
	0.76	2.79	96.44	
	4.02	5.35	4.83	
100-150 m	9.90	21.80	679.30	711.00
	0.08	0.18	5.58	5.84
	1.39	3.07	95.54	
	8.82	7.10	5.78	

Elevation	Critical	Sub-critical	Not Critical	Total
150-300 m	18.80	48.10	1,197.50	1,264.40
	0.15	0.40	9.84	10.39
	1.49	3.81	94.71	
	16.80	15.65	10.19	
300-400 m	6.60	24.50	471.90	503.00
	0.05	0.20	3.88	4.13
	1.32	4.86	93.82	
	5.94	7.95	4.02	
400-600 m	15.10	64.20	851.50	930.80
	0.12	0.53	7.00	7.65
	1.63	6.89	91.48	
	13.52	20.88	7.25	
600-800 m	17.20	28.50	627.90	673.60
	0.14	0.23	5.16	5.53
	2.55	4.24	93.21	
	15.35	9.29	5.34	
800-900 m	2.80	6.10	260.80	269.70
	0.02	0.05	2.14	2.22
	1.05	2.25	96.70	
	2.54	1.97	2.22	
900-1,000 m	2.50	5.00	240.70	248.20
	0.02	0.04	1.98	2.04
	0.99	2.02	96.99	
	2.20	1.63	2.05	
1,000-1,150 m	1.60	8.20	382.30	392.10
	0.01	0.07	3.14	3.22
	0.42	2.09	97.50	
	1.45	2.66	3.25	
1,150-1,300 m	0.90	6.40	343.80	351.10
	0.01	0.05	2.83	2.89
	0.24	1.83	97.92	
	0.76	2.09	2.93	
>1,300 m	11.70	26.80	1,490.90	1,529.50
	0.10	0.22	12.25	12.57
	0.77	1.75	97.48	
	10.49	8.71	12.69	
Total	111.90	307.40	11,751.40	12,170.80
	0.92	2.53	96.55	

Area cross tabulation of critical areas for nonpoint pollution sources with the erosion map of Benguet, La Union, Pangasinan and Tarlac.

Area (km sq)
Total %
Row %
Col %

	Critical	Sub-critical	Not Critical	Total
No erosion	14.20	26.80	4,941.90	4,982.90
	0.12	0.22	40.47	40.81
	0.29	0.54	99.18	
	12.70	8.70	41.91	
None to slight erosion	6.80	15.70	820.10	842.70
	0.06	0.13	6.72	6.90
	0.81	1.87	97.32	
	6.11	5.12	6.96	
Slight erosion	5.90	28.80	1,697.80	1,732.40
	0.05	0.24	13.90	14.19
	0.34	1.66	98.00	
	5.24	9.36	14.40	
Moderate erosion	24.30	104.70	2,565.50	2,694.50
	0.20	0.86	21.01	22.07
	0.90	3.89	95.21	
	21.71	34.05	21.76	
Severe erosion	58.90	116.40	1,532.90	1,708.20
	0.48	0.95	12.55	13.99
	3.45	6.81	89.74	
	52.64	37.86	13.00	
Very severe erosion	1.80	15.00	188.90	205.70
	0.01	0.12	1.55	1.68
	0.86	7.31	91.83	
	1.59	4.89	1.60	
Reservoir	0.00	0.00	43.80	43.90
	0.00	0.00	0.36	0.36
	0.00	0.10	99.90	
	0.00	0.01	0.37	
Total	111.90	307.40	11,790.90	12,210.30
	0.92	2.52	96.57	

Area cross tabulation of the critical area for nonpoint pollution sources within the Agno River Basin.

Area (km sq)
Total %
Row %

	Critical	Sub-critical	Not Critical	Total
Central Plain	17.07	28.94	4,038.23	4,084.24
	0.22	0.37	51.82	52.41
	0.42	0.71	98.87	
	25.32	15.05	53.61	
S1	0.58	11.41	92.23	104.22
	0.01	0.15	1.18	1.34
	0.56	10.95	88.49	
	0.86	5.94	1.22	
S2	0.07	2.32	35.48	37.87
	0.00	0.03	0.46	0.49
	0.20	6.11	93.69	
	0.11	1.20	0.47	
S3	0.07	7.87	110.39	118.34
	0.00	0.10	1.42	1.52
	0.06	6.65	93.28	
	0.11	4.10	1.47	
S4	0.00	0.94	40.08	41.02
	0.00	0.01	0.51	0.53
	0.00	2.29	97.71	
	0.00	0.49	0.53	
S5	0.00	4.33	219.13	223.46
	0.00	0.06	2.81	2.87
	0.00	1.94	98.06	
	0.00	2.25	2.91	
S6	0.37	14.18	251.65	266.20
	0.00	0.18	3.23	3.42
	0.14	5.33	94.53	
	0.55	7.37	3.34	
S7	0.00	0.73	34.10	34.84
	0.00	0.01	0.44	0.45
	0.00	2.10	97.90	
	0.00	0.38	0.45	

	Critical	Sub-critical	Not Critical	Total
S8	0.00	0.39	115.32	115.71
	0.00	0.00	1.48	1.48
	0.00	0.34	99.66	
	0.00	0.20	1.53	
S9	0.00	0.49	152.49	152.98
	0.00	0.01	1.96	1.96
	0.00	0.32	99.68	
	0.00	0.26	2.02	
S10	0.00	0.00	30.62	30.62
	0.00	0.00	0.39	0.39
	0.00	0.00	100.00	
	0.00	0.00	0.41	
S11	0.00	0.00	54.48	54.48
	0.00	0.00	0.70	0.70
	0.00	0.00	100.00	
	0.00	0.00	0.72	
S12	0.00	0.03	128.81	128.84
	0.00	0.00	1.65	1.65
	0.00	0.02	99.98	
	0.00	0.02	1.71	
S13	0.00	0.40	109.77	110.17
	0.00	0.01	1.41	1.41
	0.00	0.37	99.63	
	0.00	0.21	1.46	
S14	0.00	0.04	36.94	36.99
	0.00	0.00	0.47	0.47
	0.00	0.12	99.88	
	0.00	0.02	0.49	
S15	8.31	11.61	33.01	52.93
	0.11	0.15	0.42	0.68
	15.69	21.93	62.38	
	12.31	6.04	0.44	
S16	0.15	1.20	38.79	40.14
	0.00	0.02	0.50	0.52
	0.37	2.98	96.65	
	0.22	0.62	0.52	

	Critical	Sub-critical	Not Critical	Total
S17	0.85	3.08	7.71	11.64
	0.01	0.04	0.10	0.15
	7.32	26.44	66.24	
	1.26	1.60	0.10	
S18	3.26	7.35	32.55	43.16
	0.04	0.09	0.42	0.55
	7.55	17.03	75.42	
	4.83	3.82	0.43	
S19	2.46	3.53	48.50	54.49
	0.03	0.05	0.62	0.70
	4.52	6.47	89.01	
	3.65	1.83	0.64	
S20	1.66	9.89	112.26	123.81
	0.02	0.13	1.44	1.59
	1.34	7.99	90.67	
	2.46	5.14	1.49	
S21	6.24	10.37	84.01	100.62
	0.08	0.13	1.08	1.29
	6.21	10.30	83.49	
	9.26	5.39	1.12	
S22	0.63	1.30	56.26	58.18
	0.01	0.02	0.72	0.75
	1.08	2.23	96.69	
	0.93	0.68	0.75	
N1	2.32	5.21	46.94	54.46
	0.03	0.07	0.60	0.70
	4.25	9.57	86.18	
	3.43	2.71	0.62	
N2	0.00	0.12	8.38	8.50
	0.00	0.00	0.11	0.11
	0.00	1.41	98.59	
	0.00	0.06	0.11	
N3	1.28	3.20	39.21	43.69
	0.02	0.04	0.50	0.56
	2.94	7.32	89.74	
	1.90	1.66	0.52	

	Critical	Sub-critical	Not Critical	Total
N4	0.79	1.28	29.38	31.46
	0.01	0.02	0.38	0.40
	2.52	4.08	93.40	
	1.17	0.67	0.39	
N5	1.24	2.20	61.25	64.68
	0.02	0.03	0.79	0.83
	1.92	3.39	94.69	
	1.84	1.14	0.81	
N6	0.00	0.72	47.40	48.12
	0.00	0.01	0.61	0.62
	0.00	1.49	98.51	
	0.00	0.37	0.63	
N7	0.00	0.24	47.40	47.64
	0.00	0.00	0.61	0.61
	0.00	0.50	99.50	
	0.00	0.12	0.63	
N8	0.00	0.00	74.44	74.44
	0.00	0.00	0.96	0.96
	0.00	0.00	100.00	
	0.00	0.00	0.99	
N9	0.00	0.30	99.98	100.28
	0.00	0.00	1.28	1.29
	0.00	0.30	99.70	
	0.00	0.16	1.33	
N10	0.00	0.00	74.62	74.62
	0.00	0.00	0.96	0.96
	0.00	0.00	100.00	
	0.00	0.00	0.99	
N11	0.00	2.75	139.82	142.57
	0.00	0.04	1.79	1.83
	0.00	1.93	98.07	
	0.00	1.43	1.86	
N12	0.73	1.70	93.26	95.69
	0.01	0.02	1.20	1.23
	0.76	1.78	97.46	
	1.09	0.89	1.24	

	Critical	Sub-critical	Not Critical	Total
N13	1.28	2.17	84.18	87.63
	0.02	0.03	1.08	1.12
	1.47	2.47	96.06	
	1.90	1.13	1.12	
N14	0.00	1.31	103.85	105.17
	0.00	0.02	1.33	1.35
	0.00	1.25	98.75	
	0.00	0.68	1.38	
N15	0.00	0.03	114.44	114.47
	0.00	0.00	1.47	1.47
	0.00	0.03	99.97	
	0.00	0.02	1.52	
N16	0.00	0.00	10.29	10.29
	0.00	0.00	0.13	0.13
	0.00	0.00	100.00	
	0.00	0.00	0.14	
N17	1.85	2.21	51.31	55.38
	0.02	0.03	0.66	0.71
	3.35	3.99	92.66	
	2.75	1.15	0.68	
N18	0.18	2.12	10.77	13.07
	0.00	0.03	0.14	0.17
	1.37	16.23	82.40	
	0.27	1.10	0.14	
N19	0.00	0.00	5.03	5.03
	0.00	0.00	0.06	0.06
	0.00	0.00	100.00	
	0.00	0.00	0.07	
N20	4.78	7.04	16.09	27.90
	0.06	0.09	0.21	0.36
	17.13	25.21	57.66	
	7.09	3.66	0.21	
N21	0.76	5.36	14.04	20.17
	0.01	0.07	0.18	0.26
	3.78	26.59	69.63	
	1.13	2.79	0.19	

	Critical	Sub-critical	Not Critical	Total
N22	2.26	4.18	13.59	20.03
	0.03	0.05	0.17	0.26
	11.26	20.88	67.86	
	3.34	2.18	0.18	
N23	0.39	0.73	2.29	3.41
	0.00	0.01	0.03	0.04
	11.40	21.49	67.11	
	0.58	0.38	0.03	
N24	0.19	0.22	14.91	15.33
	0.00	0.00	0.19	0.20
	1.27	1.46	97.27	
	0.29	0.12	0.20	
N25	0.42	5.36	18.45	24.23
	0.01	0.07	0.24	0.31
	1.73	22.13	76.14	
	0.62	2.79	0.24	
N26	0.00	0.00	21.36	21.36
	0.00	0.00	0.27	0.27
	0.00	0.00	100.00	
	0.00	0.00	0.28	
N27	0.00	0.00	28.11	28.11
	0.00	0.00	0.36	0.36
	0.00	0.00	100.00	
	0.00	0.00	0.37	
N28	0.28	0.07	51.33	51.69
	0.00	0.00	0.66	0.66
	0.55	0.14	99.31	
	0.42	0.04	0.68	
N29	0.00	0.00	6.50	6.50
	0.00	0.00	0.08	0.08
	0.00	0.00	100.00	
	0.00	0.00	0.09	
N30	0.00	0.01	10.20	10.22
	0.00	0.00	0.13	0.13
	0.00	0.15	99.85	
	0.00	0.01	0.14	

	Critical	Sub-critical	Not Critical	Total
N31	0.96	1.84	11.73	14.52
	0.01	0.02	0.15	0.19
	6.58	12.65	80.76	
	1.42	0.96	0.16	
N32	0.00	0.07	13.09	13.16
	0.00	0.00	0.17	0.17
	0.00	0.57	99.43	
	0.00	0.04	0.17	
N33	0.00	0.01	31.40	31.42
	0.00	0.00	0.40	0.40
	0.00	0.05	99.95	
	0.00	0.01	0.42	
N34	2.58	5.45	53.39	61.43
	0.03	0.07	0.69	0.79
	4.21	8.88	86.92	
	3.83	2.84	0.71	
N35	1.63	4.88	69.06	75.57
	0.02	0.06	0.89	0.97
	2.15	6.46	91.38	
	2.41	2.54	0.92	
N36	0.93	6.48	91.83	99.23
	0.01	0.08	1.18	1.27
	0.93	6.53	92.53	
	1.37	3.37	1.22	
N37	0.85	4.54	60.57	65.97
	0.01	0.06	0.78	0.85
	1.29	6.88	91.83	
	1.26	2.36	0.80	
Total	67.45	192.23	7,532.73	7,792.40
	0.87	2.47	96.67	

Area cross tabulation of the critical areas for nonpoint pollution sources in the municipalities of Pangasinan.

Area (km sq)
Total %
Row %
Col %

Municipal/ Islands	Critical	Sub-critical	Not Critical	Total
San Fabian	0.00	0.81	74.45	75.26
	0.00	0.02	1.47	1.48
	0.00	1.07	98.93	
	0.00	0.53	1.53	
Mangaldan	0.00	0.00	45.68	45.68
	0.00	0.00	0.90	0.90
	0.00	0.00	100.00	
	0.00	0.00	0.94	
Dagupan	0.00	0.00	50.67	50.67
	0.00	0.00	1.00	1.00
	0.00	0.00	100.00	
	0.00	0.00	1.04	
Calasiao	0.00	0.00	53.21	53.21
	0.00	0.00	1.05	1.05
	0.00	0.00	100.00	
	0.00	0.00	1.10	
Binmaley	0.00	0.00	48.06	48.06
	0.00	0.00	0.95	0.95
	0.00	0.00	100.00	
	0.00	0.00	0.99	
San Carlos	0.00	0.00	177.72	177.72
	0.00	0.00	3.50	3.50
	0.00	0.00	100.00	
	0.00	0.00	3.66	
Lingayen	0.00	0.00	59.72	59.72
	0.00	0.00	1.18	1.18
	0.00	0.00	100.00	
	0.00	0.00	1.23	

Municipal/ Islands	Critical	Sub-critical	Not Critical	Total
Labrador	3.09	3.08	107.47	113.64
	0.06	0.06	2.12	2.24
	2.72	2.71	94.57	
	4.44	2.01	2.21	
Sual	1.81	0.79	142.63	145.23
	0.04	0.02	2.81	2.86
	1.24	0.55	98.21	
	2.60	0.52	2.94	
Alaminos	0.28	1.70	158.66	160.65
	0.01	0.03	3.12	3.16
	0.18	1.06	98.76	
	0.41	1.11	3.27	
Bani	0.88	5.78	211.62	218.28
	0.02	0.11	4.17	4.30
	0.40	2.65	96.95	
	1.27	3.78	4.36	
Bolinao	0.81	4.17	157.63	162.60
	0.02	0.08	3.10	3.20
	0.50	2.56	96.94	
	1.16	2.73	3.25	
Anda	0.00	2.99	71.12	74.11
	0.00	0.06	1.40	1.46
	0.00	4.03	95.97	
	0.00	1.95	1.46	
Silaqui	0.00	0.00	0.13	0.13
	0.00	0.00	0.00	0.00
	0.00	0.00	100.00	
	0.00	0.00	0.00	
Santiago	0.00	0.00	21.51	21.51
	0.00	0.00	0.42	0.42
	0.00	0.00	100.00	
	0.00	0.00	0.44	
Siapar	0.00	0.00	2.02	2.02
	0.00	0.00	0.04	0.04
	0.00	0.00	100.00	
	0.00	0.00	0.04	

Municipal/ Islands	Critical	Sub-critical	Not Critical	Total
Hundred Islands	0.00	1.20	100.00	0.00
	0.00	0.00	0.02	0.02
	0.00	0.00	100.00	
	0.00	0.00	0.02	
Cabalitian	0.00	0.00	1.69	1.69
	0.00	0.00	0.03	0.03
	0.00	0.00	100.00	
	0.00	0.00	0.03	
Agno	1.22	9.55	127.86	138.63
	0.02	0.19	2.52	2.73
	0.88	6.89	92.23	
	1.76	6.24	2.63	
Burgos	0.88	8.07	114.14	123.09
	0.02	0.16	2.25	2.42
	0.72	6.55	92.73	
	1.27	5.28	2.35	
Mabini	11.71	16.73	198.38	226.82
	0.23	0.33	3.91	4.47
	5.16	7.38	87.46	
	16.83	10.94	4.09	
Dasol	0.70	11.13	158.57	170.40
	0.01	0.22	3.12	3.36
	0.41	6.53	93.06	
	1.01	7.28	3.27	
Infanta	2.36	3.78	227.73	233.87
	0.05	0.07	4.48	4.61
	1.01	1.62	97.37	
	3.39	2.47	4.69	
Bugallon	5.14	14.34	136.07	155.55
	0.10	0.28	2.68	3.06
	3.30	9.22	87.48	
	7.39	9.38	2.80	
Aguilar	5.89	11.77	126.93	144.59
	0.12	0.23	2.50	2.85
	4.07	8.14	87.79	
	8.46	7.70	2.61	

Municipal/ Islands	Critical	Sub-critical	Not Critical	Total
Pozorubbio	1.37	0.42	77.84	79.64
	0.03	0.01	1.53	1.57
	1.73	0.53	97.75	
	1.98	0.27	1.60	
Sison	3.24	3.72	105.06	112.02
	0.06	0.07	2.07	2.21
	2.89	3.32	93.79	
	4.66	2.43	2.16	
Binalonan	0.00	0.00	65.00	65.00
	0.00	0.00	1.28	1.28
	0.00	0.00	100.00	
	0.00	0.00	1.34	
Urdaneta	0.00	0.00	128.30	128.30
	0.00	0.00	2.53	2.53
	0.00	0.00	100.00	
	0.00	0.00	2.64	
Asingan	0.00	0.00	74.60	74.60
	0.00	0.00	1.47	1.47
	0.00	0.00	100.00	
	0.00	0.00	1.54	
San Manuel	1.88	1.88	112.17	115.94
	0.04	0.04	2.21	2.28
	1.62	1.62	96.75	
	2.71	1.23	2.31	
San Nicolas	13.09	24.96	181.87	219.92
	0.26	0.49	3.58	4.33
	5.95	11.35	82.70	
	18.81	16.32	3.75	
Tayug	0.00	0.00	43.44	43.44
	0.00	0.00	0.86	0.86
	0.00	0.00	100.00	
	0.00	0.00	0.89	
Natividad	0.84	6.14	78.77	85.75
	0.02	0.12	1.55	1.69
	0.98	7.16	91.86	
	1.20	4.02	1.62	

Municipal/ Islands	Critical	Sub-critical	Not Critical	Total
Mangatarem	9.13	16.39	261.09	286.61
	0.18	0.32	5.14	5.64
	3.18	5.72	91.10	
	13.12	10.72	5.38	
Urbiztondo	0.00	0.00	53.96	53.96
	0.00	0.00	1.06	1.06
	0.00	0.00	100.00	
	0.00	0.00	1.11	
Basista	0.00	0.00	29.89	29.89
	0.00	0.00	0.59	0.59
	0.00	0.00	100.00	
	0.00	0.00	0.62	
Malasiqui	0.87	0.82	117.53	119.22
	0.02	0.02	2.31	2.35
	0.73	0.69	98.58	
	1.25	0.54	2.42	
Sta. Barbara	0.00	0.00	69.40	69.40
	0.00	0.00	1.37	1.37
	0.00	0.00	100.00	
	0.00	0.00	1.43	
Mapandan	0.00	0.00	21.94	21.94
	0.00	0.00	0.43	0.43
	0.00	0.00	100.00	
	0.00	0.00	0.45	
San Jacinto	0.00	0.00	30.32	30.32
	0.00	0.00	0.60	0.60
	0.00	0.00	100.00	
	0.00	0.00	0.62	
Manaoag	1.93	1.14	42.84	45.91
	0.04	0.02	0.84	0.90
	4.20	2.47	93.33	
	2.77	0.74	0.88	
Laoac	0.00	0.00	31.24	31.24
	0.00	0.00	0.62	0.62
	0.00	0.00	100.00	
	0.00	0.00	0.64	

Municipal/ Islands	Critical	Sub-critical	Not Critical	Total
San Quintin	0.00	0.00	114.19	114.19
	0.00	0.00	2.25	2.25
	0.00	0.00	100.00	
	0.00	0.00	2.35	
Sta. Maria	0.00	0.00	48.71	48.71
	0.00	0.00	0.96	0.96
	0.00	0.00	100.00	
	0.00	0.00	1.00	
Umingan	0.00	0.00	257.76	257.76
	0.00	0.00	5.08	5.08
	0.00	0.00	100.00	
	0.00	0.00	5.31	
Balungan	0.00	0.00	76.63	76.63
	0.00	0.00	1.51	1.51
	0.00	0.00	100.00	
	0.00	0.00	1.58	
Rosales	0.00	0.00	65.86	65.86
	0.00	0.00	1.30	1.30
	0.00	0.00	100.00	
	0.00	0.00	1.36	
Villasis	0.91	0.28	77.38	78.58
	0.02	0.01	1.52	1.55
	1.16	0.36	98.48	
	1.31	0.19	1.59	
Sto. Tomas	0.00	0.00	12.79	12.79
	0.00	0.00	0.25	0.25
	0.00	0.00	100.00	
	0.00	0.00	0.26	
Alcala	1.55	1.46	41.95	44.96
	0.03	0.03	0.83	0.89
	3.46	3.26	93.29	
	2.23	0.96	0.86	
Bautista	0.00	0.00	68.15	68.15
	0.00	0.00	1.34	1.34
	0.00	0.00	100.00	
	0.00	0.00	1.40	

Municipal/ Islands	Critical	Sub-critical	Not Critical	Total
Bayambang	0.00	1.02	92.08	93.10
	0.00	0.02	1.81	1.83
	0.00	1.09	98.91	
	0.00	0.66	1.90	
Total	69.58	152.91	4,855.66	5,078.15
	1.37	3.01	95.62	

Area cross tabulation of the critical areas for nonpoint pollution sources in the municipalities of Benguet

Area (km sq.)
Total %
Row%
Col %

	Not Critical	Sub-critical	Critical	Total
Bakun	165.78	0.00	0.00	165.78
	6.05	0.00	0.00	6.05
	100.00	0.00	0.00	
	6.20	0.00	0.00	
Mankayan	234.75	0.00	0.00	234.75
	8.57	0.00	0.00	8.57
	100.00	0.00	0.00	
	8.77	0.00	0.00	
Buguias	106.49	9.62	5.42	121.54
	3.89	0.35	0.20	4.44
	87.62	7.92	4.46	
	3.98	21.09	30.95	
Kibungan	161.08	0.64	0.63	162.35
	5.88	0.02	0.02	5.93
	99.22	0.40	0.39	
	6.02	1.41	3.58	
Kabayan	153.73	3.32	1.24	158.29
	5.61	0.12	0.05	5.78
	97.12	2.10	0.78	
	5.75	7.27	7.08	
Atok	138.51	0.34	0.00	138.85
	5.06	0.01	0.00	5.07
	99.75	0.25	0.00	
	5.18	0.75	0.00	
Kapangan	145.62	0.45	0.12	146.19
	5.32	0.02	0.00	5.34
	99.61	0.31	0.08	
	5.44	0.98	0.68	
Tublay	93.74	1.02	0.88	95.63
	3.42	0.04	0.03	3.49
	98.02	1.06	0.92	
	3.50	2.23	5.03	

	Not Critical	Sub-critical	Critical	Total
Sablan	103.99	1.48	0.21	105.67
	3.80	0.05	0.01	3.86
	98.40	1.40	0.20	
	3.89	3.24	1.19	
La Trinidad	75.42	1.49	1.34	78.26
	2.75	0.05	0.05	2.86
	96.37	1.91	1.72	
	2.82	3.28	7.67	
Tuba	330.87	15.48	4.15	350.50
	12.08	0.57	0.15	12.80
	94.40	4.42	1.18	
	12.37	33.93	23.70	
Baguio	50.91	4.59	1.66	57.15
	1.86	0.17	0.06	2.09
	89.07	8.02	2.90	
	1.90	10.06	9.46	
Itogon	546.05	6.66	1.87	554.58
	19.94	0.24	0.07	20.25
	98.46	1.20	0.34	
	20.41	14.61	10.66	
Bokod	368.53	0.52	0.00	369.05
	13.46	0.02	0.00	13.48
	99.86	0.14	0.00	
	13.77	1.15	0.00	
Total	2,675.47	45.61	17.52	2,738.60
	97.69	1.67	0.64	

Area cross tabulation of critical areas for nonpoint pollution sources in the municipalities of Tarlac.

Area (km sq.)
Total %
Row %
Col %

Municipal	Critical	Sub-critical	Not Critical	Total
Bamban	2.12	9.58	133.44	145.14
	0.07	0.31	4.35	4.73
	1.46	6.60	91.94	
	62.01	16.13	4.44	
Concepcion	0.00	0.00	214.32	214.32
	0.00	0.00	6.98	6.98
	0.00	0.00	100.00	
	0.00	0.00	7.13	
O'Donnel	1.02	31.36	482.01	514.38
	0.03	1.02	15.70	16.75
	0.20	6.10	93.71	
	29.69	52.81	16.03	
Tarlac	0.28	16.82	740.18	757.28
	0.01	0.55	24.11	24.66
	0.04	2.22	97.74	
	8.30	28.33	24.61	
La Paz	0.00	0.00	123.14	123.14
	0.00	0.00	4.01	4.01
	0.00	0.00	100.00	
	0.00	0.00	4.09	
Victoria	0.00	0.00	121.52	121.52
	0.00	0.00	3.96	3.96
	0.00	0.00	100.00	
	0.00	0.00	4.04	
Pura	0.00	0.00	32.74	32.74
	0.00	0.00	1.07	1.07
	0.00	0.00	100.00	
	0.00	0.00	1.09	

Municipal	Critical	Sub-critical	Not Critical	Total
Gerona	0.00	0.54	118.70	119.24
	0.00	0.02	3.87	3.88
	0.00	0.45	99.55	
	0.00	0.91	3.95	
Sta. Ignasia	0.00	0.66	117.07	117.73
	0.00	0.02	3.81	3.83
	0.00	0.56	99.44	
	0.00	1.11	3.89	
Mayantoc	0.00	0.03	349.17	349.20
	0.00	0.00	11.37	11.37
	0.00	0.01	99.99	
	0.00	0.05	11.61	
Camiling	0.00	0.31	183.20	183.52
	0.00	0.01	5.97	5.98
	0.00	0.17	99.83	
	0.00	0.53	6.09	
Paniqui	0.00	0.00	94.14	94.14
	0.00	0.00	3.07	3.07
	0.00	0.00	100.00	
	0.00	0.00	3.13	
Ramos	0.00	0.00	31.67	31.67
	0.00	0.00	1.03	1.03
	0.00	0.00	100.00	
	0.00	0.00	1.05	
Nampicuan	0.00	0.00	25.37	25.37
	0.00	0.00	0.83	0.83
	0.00	0.00	100.00	
	0.00	0.00	0.84	
Moncada	0.00	0.00	119.95	119.95
	0.00	0.00	3.91	3.91
	0.00	0.00	100.00	
	0.00	0.00	3.99	
San Manuel	0.00	0.00	50.01	50.01
	0.00	0.00	1.63	1.63
	0.00	0.00	100.00	
	0.00	0.00	1.66	

Municipal	Critical	Sub-critical	Not Critical	Total
San Clemente	0.00	0.09	71.08	71.17
	0.00	0.00	2.31	2.32
	0.00	0.13	99.87	
	0.00	0.15	2.36	
Total	3.42	59.38	3,007.72	3,070.52
	0.11	1.93	97.95	

Area cross tabulation of critical areas for nonpoint pollution sources in the municipalities of La Union.

Area (km sq.)
Total %
Row %
Col %

Municipal	Critical	Sub-critical	Not Critical	Total
Bangar	0.48	0.19	40.75	41.42
	0.03	0.01	2.84	2.88
	1.15	0.47	98.38	
	2.23	0.38	2.99	
Luna	0.81	0.60	39.03	40.44
	0.06	0.04	2.72	2.81
	1.99	1.48	96.53	
	3.77	1.18	2.86	
Balaoan	0.00	0.00	69.90	69.90
	0.00	0.00	4.87	4.87
	0.00	0.00	100.00	
	0.00	0.00	5.12	
Bacnotan	1.21	3.93	60.05	65.19
	0.08	0.27	4.18	4.54
	1.86	6.03	92.12	
	5.65	7.75	4.40	
San Juan	0.96	3.72	55.57	60.25
	0.07	0.26	3.87	4.19
	1.59	6.17	92.24	
	4.46	7.34	4.07	
San Fernando	0.54	2.00	96.26	98.80
	0.04	0.14	6.70	6.88
	0.54	2.03	97.43	
	2.51	3.95	7.05	
Bauang	3.60	3.88	68.34	75.83
	0.25	0.27	4.76	5.28
	4.75	5.12	90.13	
	16.81	7.66	5.01	
Caba	0.00	0.00	49.46	49.46
	0.00	0.00	3.44	3.44
	0.00	0.00	100.00	
	0.00	0.00	3.62	

Municipal	Critical	Sub-critical	Not Critical	Total
Aringay	4.11	10.55	83.79	98.44
	0.29	0.73	5.83	6.85
	4.17	10.71	85.11	
	19.18	20.81	6.14	
Agoo	0.04	0.25	38.82	39.12
	0.00	0.02	2.70	2.72
	0.11	0.65	99.24	
	0.21	0.50	2.85	
Sto. Tomas	0.00	0.54	61.32	61.86
	0.00	0.04	4.27	4.31
	0.00	0.87	99.13	
	0.00	1.06	4.49	
Rosario	1.24	1.27	66.73	69.24
	0.09	0.09	4.64	4.82
	1.79	1.83	96.38	
	5.79	2.51	4.89	
Pugo	0.03	1.93	41.62	43.57
	0.00	0.13	2.90	3.03
	0.07	4.42	95.51	
	0.14	3.80	3.05	
Tubao	2.02	4.06	50.76	56.84
	0.14	0.28	3.53	3.96
	3.55	7.15	89.30	
	9.41	8.02	3.72	
Naguilian	5.15	7.33	82.49	94.98
	0.36	0.51	5.74	6.61
	5.43	7.72	86.85	
	24.06	14.47	6.05	
Burgos	0.81	1.31	60.86	62.98
	0.06	0.09	4.24	4.38
	1.28	2.09	96.63	
	3.77	2.59	4.46	
Bagulin	0.00	3.66	67.19	70.85
	0.00	0.25	4.68	4.93
	0.00	5.17	94.83	
	0.00	7.22	4.92	
San Gabriel	0.24	4.88	150.55	155.67
	0.02	0.34	10.48	10.84
	0.15	3.14	96.71	
	1.12	9.64	11.03	

Municipal	Critical	Sub-critical	Not Critical	Total
Santol	0.00	0.00	112.83	112.83
	0.00	0.00	7.85	7.85
	0.00	0.00	100.00	
	0.00	0.00	8.27	
Sudipen	0.19	0.57	68.15	68.91
	0.01	0.04	4.74	4.80
	0.28	0.82	98.89	
	0.91	1.12	4.99	
Total	21.42	50.69	1,364.48	1,436.58
	1.49	3.53	94.98	

A Study on the Sediment Loading of the Agno River Basin due to Surface Erosion Using Geographic Information Systems[1]

James N. Paw[2]

Sediment loading of the Agno River Basin can be estimated using the Universal Soil Loss Equation (USLE). McElroy et al. (1976) defined sediment loading as "the quantity of soil material that is eroded and transported into the watercourse. It is dependent on *in situ* erosion and delivery or the ability of runoff to carry the eroded material into the receptor water." It is an empirical, deterministic and lumped model using regression analysis.

The sediment loading function is:

$$Y(S)_E = \sum_{i=1}^{n} [A_i(R \cdot K \cdot L \cdot S \cdot C \cdot P \cdot S_d)_1] \quad (1)$$

Where

$Y(S)_E$	=	sediment loading from surface erosion, t/yr
n	=	number of subareas in the study area
A_i	=	areal extent of subarea i, km^2
R	=	rainfall erosivity factor, mm
K	=	soil erodibility factor, t/ha per R unit
L	=	slope-length factor, dimensionless ratio
S	=	slope-steepness factor, dimensionless ratio
C	=	vegetation cover factor (land use), dimensionless ratio
P	=	erosion control practice factor, dimensionless ratio
S_d	=	sediment delivery ratio, dimensionless

Applicability

The USLE can be used to predict sediment loading resulting from sheet and rill erosion of noncrop- and croplands. The equation does not predict sediment contributions from gully erosion, streambank erosion or mass soil movement.

1 Activity 1 of the GISCAMP Project.

2 International Center for Living Aquatic Resources Management (ICLARM), MC P.O. Box 2631, Makati, Philippines.

Procedure to Use the Sediment Loading Function

The procedure to use the USLE is based on McElroy et al. (1976). Surface erosion should be estimated for each land use type. If ≥90% of the area consist of one soil type, soil loss calculation for land use may be based on that soil type. If one soil type is <90%, soil loss calculation should be based on each soil type that makes up at least 10% of the land use and then obtain a weighted average for the entire land use area.

Parameters and Basic Data Required

Study Area (A)

The entire Agno River Basin is situated in 9 provinces with headwaters in the boundary of Benguet and Ifugao. The study area, however, comprises 4 provinces - Benguet, La Union, Pangasinan and Tarlac. Sub-basins situated in La Union and the southwest part of Benguet such as the Bued and Pantalan Rivers are allied basins of the Agno River Basin.

The base map of the study area is constructed from 1:250,000 topographic maps (UTM) published by the National Mapping and Resource Information Authority (NAMRIA). The overall basin boundaries have been delineated based on the studies conducted by the National Irrigation Authority (NIA) and the Department of Public Works and Highways (DPWH). For the study area, the eastern, southern and southwestern boundaries followed the provincial boundaries of the 4 provinces instead of the actual delineated basin boundaries. The provincial boundaries were constructed from 1:50,000 topographic map (UTM) published by NAMRIA.

The Agno River Basin has been divided into 3 sub-areas. These are the northeastern mountainous sub-area, Pangasinan central plain and the southwestern mountainous sub-area. Except for the Pangasinan central plain, the 2 mountainous sub-areas have been sub-divided into sub-basins based on the boundaries set by the Agno River Basin Study under the Japan International Cooperation Agency (JICA) and DPWH. There are 60 sub-basins in the study. The unit used is in km^2.

Rainfall Factor (R)

The rainfall factor (R) is defined by McElroy et al. (1976) as "expressing the erosion potential of average annual rainfall in the locality, is a summation of the individual storm products of the kinetic energy of rainfall, in hundreds of m-t/ha-cm, and the maximum 30-min rainfall intensity, in cm/hr, for all significant storms, on an average annual basis. The R is also called index of erosivity and erosion index. When lines are drawn to connect points with the same erosion index value such lines are called iso-erodents and a map showing such lines is known as iso-erodent map.

The R can be derived using the following formula (David 1987):

$$R = A \bullet P_i^m \tag{2}$$

where

R = daily rainfall > 25 mm
i = counter for the days of the year (number of days with rainfall >25 mm)
A = 0.002
m = 2.0

Precipitation records on a daily basis are generally difficult to obtain although in the case of the rainfall stations in the Agno River Basin, they are available for most of the stations. Eq. 2 is usually not convenient to use, particularly if daily rainfall data are not available. In this study, an empirical formula developed by Roose (1977) for a large part of West Africa as reported by Mitchell and Bubenzer (1980) was used.

$$R_{an}/H_{an} = 0.50 \pm 0.05 \qquad (3)$$

where R_{an} = average annual erosivity index
H_{an} = average annual rainfall amount, mm

An iso-erodent or isohyetal map was constructed using annual rainfall values in 34 rainfall stations with at least 10 years continuous records. The 34 stations are located within and outside of the Agno River Basin.

Soil Erodibility Factor (K)

The soil erodibility factor (K) is a quantitative measure of the rate at which a soil will erode and expressed as t/ha per unit of R. It is independent of the effect of management. Typically, a nomograph is used to determine the K but generally, the calculated values may be inaccurate or even meaningless because of geographical variability. Another method of estimating K is by using the formula described by David (1985) as follow:

$$K = [(0.043)(pH) + (0.62/OM) + 0.0825(Sa) - 0.0062(C)]Si \qquad (4)$$

Where pH = soil pH
OM= percent organic matter
Sa = percent sand
C = clay ratio = % clay/(% sand + % silt)
Si = % silt/100

The difficulty in using Eq. 4 is that detailed soil data is required (physio-chemical paramaters). Since most soil data were collected from a reconnaissance level survey, details on soil types are sometimes not available. In this study, a table showing organic matter content versus soil types were used in determining the K factor. See Annex 1 for details. A soil texture table with the corresponding organic matter content and K factor was constructed.

Slope Length - Gradient Factor (LS)

The slope length - gradient factor is a combination of slope length (L) and slope steepness (S). Erosion process is typically high in steep slopes, especially where there is low vegetation cover. The LS defines the transport portion of the erosion process where it influences the flow and velocity of runoff. The slope length factor (L) is the ratio of soil loss from a specific length of slope usually referred to as horizontal slope length to the slope length of the USLE unit equivalent to 22.13 m (72.6 ft). It is defined as the "distance from the point of origin of overland flow to the point where deposition begins, or the runoff water enters a well-defined channel that may be part of a drainage network." This is represented by the following equation (Wischmeier and Smith 1978):

$$L = (l / l_u)^m \tag{5}$$

where
L = slope length factor
l = horizontal slope length
l_u = slope length of the USLE unit plot
= 22.13 m
m = slope length exponent

The slope length exponent (m) has a value of 0.5 for slope of 9% and slope length of 22.13 m as inferred from the data of Wischmeier (see McCool et al. 1989). Thus, the LS value is 1.0 (McElroy et al. 1076). The slope length exponent varies according to slope steepness. It increases from 0.2 to 0.5 with slope steepness increasing from 0 to 5%. Above 5%, the value 0.5 is recommended (McCool et al. 1989). The constraint in using Eq. 5 is that it cannot be generalized for use in humid tropical conditions as the effect of slope gradient is considered more pronounced than in temperate countries. Another variation of Eq. (5) from Cruz (1990) for the Ibulao watershed in Laguna, Philippines can be used.

$$LS = [4.705(L/22.13)^m][(7.6 + 5.3S + 0.76S^2)10^{-3}] \tag{6}$$

where
L = slope length
S = slope gradient of the area
m = slope length exponent

L is computed using the following formula:

$$L = 0.5\ (A_t/L_c) \tag{7}$$

where
A_t = area of a cell, km^2
L_c = length of a cell, km

The slope length exponent will vary according to slope steepness:

$m = 0.5$	if $S > 5\%$
$m = 0.4$	if $5\% > S > 3\%$
$m = 0.3$	if $3\% > S > 1\%$
$m = 0.2$	if $S < 1\%$

Areas with rugged reliefs make it difficult to determine the LS factor. Construction of an elevation map to estimate the LS factor would be best done using digital elevation models (DEMs) but are usually unavailable. Alternately, elevation map can be constructed through surface interpolation by Triangulated Irregular Network (TIN) technique using digitized spot heights and points at various contour levels. This method requires substantial number of points to capture rugged reliefs.

For this study, the LS factor was computed using the following equation (David 1987):

$$LS = 0.10 + 0.21(S^{4/3}) \tag{8}$$

where S = slope in percent

A slope map (S) prepared by the BSWM was digitized. Using Eq. 8, the LS factor is computed at various slope level.

Crop Cover Factor (C)

The crop cover factor (C) is also known as crop management or cover management factor. It represents the ratio of soil quantity eroded from land that is cropped or treated under specified condition to corresponding loss (eroded) from clean-tilled fallow under identical slope and rainfall conditions. It reflects the protective influence of vegetation and ground cover. With respect to croplands (agriculture), cropping year is usually divided into 6 periods (Wischmeier and Smith 1978):

Period F	Rough fallow - turn plowing to seeding.
Period SB	Seedbed - seeding to 1 month thereafter or 10% canopy cover.
Period 1	Establishment - from 1 to 2 months after seeding or 50% canopy cover.
Period 2	Development - growing crop, 75% canopy cover.
Period 3	Maturing crop - end of period 2 to crop harvest.
Period 4	Residue or stubble - from crop harvest to turn plow or new seedbed.

The 6 cropping stages can be used for cereals, fruits and vegetables. In the Philippines, large area cultivation of vegetables and fruits (e.g., pineapple) is generally few unlike rice and corn. Hence, the C factor will vary for rice, corn, selected fruits and vegetables based on various cropping stages. For our purpose, however, vegetables will be classified under diversified crops.

The C factor enumerated below are taken from David (1987). Although the C factors have not been properly assessed, studies done in Pantabangan and Magat Reservoirs showed that the USLE results (using the C factors enumerated below) agreed well with the sediment deposition in the two reservoirs. Since the C factors of some land use units (e.g., fishponds, filling ponds) are not listed by David (1987; David and Collado, n.d.), the C factors were determined based on the probable behaviour of soil eroding from such units. For example, fishponds are generally located in flat areas and contain substantial erosion control bunds. Soil erosion would behave very similarly to irrigated rice fields. Hence, the C factor of fishponds would be the same as irrigated rice fields.

The following are the C values as applied to Philippine condition by David (1987).

Cover	**C Value**
Bare Soil	1.0
Primary forest (with dense undergrowth)	0.001
Second-growth forest with good undergrowth and high mulch cover	0.003
Second-growth forest with patches of shrubs and plantation crops of 5 yrs or more	0.006
Industrial tree plantation (ITP)	
Benguet Pine with high mulch cover	0.007
Mahogany, Narra, 3-8 yrs with good cover crop	0.05-0.10
Mahogany, Narra, 8 yrs or more with good undergrowth	0.01-0.05
Yemane, 8 yrs or more	0.08
Mixed stand of ITP plant species, 8 yrs or more	0.07

Agroforestry tree species

Cashew, mango and jackfruit, <3 yrs, withoutintercrop and with ring weeding	0.25
Cashew, mango and jackfruit, 3 to 5 yrs without intercrop and with ring weeding	0.15
Cashew, mango and jackfruit, with intercrop or native grass undercover	0.08
Mixed stand of agroforestry species, 5 yrs or more with good cover	0.08
Coconut with tree intercrops	0.05-0.10
Coconuts, with annual crops as intercrop	0.10-0.30
Ipil-ipil, good stand, 1st yr with native grass intercrop	0.20
Ipil-ipil, good stand, 2 yrs or more with high mulch cover	0.10
Ipil-ipil, newly cut for leaf meal or charcoal	0.30

Grasslands

Imperata or themeda grasslands, well established and undisturbed, with shrub	0.007
Imperata or themeda grasslands, slightly grazed, with patches of shrub	0.15
Shrubs with patches of open, disturbed grasslands	0.15
Well-managed rangeland, slightly grazed cover of slow development, 1st yr	0.3-0.8
Well-managed rangeland cover of fast development, 1st yr, ungrazed	0.05-0.10
Well-managed rangeland, slightly grazed cover of slow development, 2 yrs or more	0.01-0.10
Well-managed rangeland, cover of fast development, ungrazed, 2 yrs or more	0.01-0.05
Grassland, moderately grazed, occasionally	0.20-0.40
Overgrazed grasslands, burned regularly	0.40-0.90

Annual cash crops

Corn, sorghum	0.30-0.60
Rice	0.10-0.20
Peanut, mungbean, soybean	0.30-0.50
Cotton, tobacco	0.40-0.60
Pineapple	0.20-0.50
Bananas	0.10-0.30
Diversified crops	0.20-0.40
New kaingin areas, diversified crops	0.30
Old kaingin areas, diversified crops	0.80

Others

Built-up rural areas, with home gardens	0.20
Riverwash	0.50
Reservoir	0.20
Filling ponds	0.20
Mining areas	0.50
Fishponds	0.20
Saltbeds	0.20

The C in the GIS is represented by the Land Use map also shows vegetation cover including special areas like built-up areas (settlements), marginal lands and riverwash, etc. A table is created showing the different land use classes with corresponding class values. A separate column is inserted and the C values (above) encoded corresponding to the different land use classes. Note that when constructing the land use map, it is important that both dominant and associated crops (based on land area) should be assessed, particularly for agricultural areas.

Erosion Control Practice Factor (P)

The erosion control practice factor (P) is also referred to as conservation practice factor or simply the practice factor. The P accounts for control practices that reduce the effect of erosion due to runoff by their influence on drainage patterns, runoff concentration and runoff velocity (McElroy et al. 1976). It is the ratio of soil loss from specified conservation practice to the soil loss due to ploughing up and down the steepest slope. The worst case scenario, therefore, will have a P value of 1.0. A value of 1.0 also denotes the non-existence of conservation, particularly for non-vegetated areas (e.g., beach areas). Examples of conservation practices are terracing and contour ridges which effectively change slope characteristics, particularly in areas where slope is steep (e.g., hills and mountains).

The quantitative effect of terracing, once constructed, can be accounted by the slope length factor, L since the horizontal terrace interval becomes the slope length. The P factors for some of land use units have been determined similar to that for C factor. For example, built-up areas or settlements have many impervious surfaces (roads, parking lots, buildings) which are not erodible compared to bare soil. Hence, the P factor would be the same as a surface covered with 80 to 100% legume like *Centrosema*. The P values from various conservation practices in the Philippines and shown below were taken from David (1987).

Crop Management		**P**
Cashew orchard		
1.	Establish grass intercrop like centrosema, 80% surface cover	0.11
2.	Grass intercrop, 60% surface cover	0.23
3.	Broad-based terraces	0.20
4.	Broad-based terraces with cover intercrop at 80% cover	0.23
Corn		
1.	Contour-strip cropping	0.40-0.50
2.	Zoned tillage	0.25
3.	Zoned tillage with contouring	0.90-0.95
4.	Zoned tillage, contour farming and mulching at 40% cover	0.40
5.	Broad-based terraces, contouring and mulching at 40% cover	0.18-0.20
6.	Broad-based terraces with mulch tillage contour farming	0.26
7.	Broad-based terraces, mulching at 80% cover and contouring	0.15
8.	Broad-based terraces, zoned tillage and contouring	0.25
Old Kaingin		
1.	Contour strip cropping, mulching at 60% cover, zoned tillage contour farming	0.30

With GIS, P values are tabulated relative to specific land use units. It may be necessary for one dominant land use to have different P factor based on different associated crops.

Typically, C*P column is constructed alongside the C column of a C table.

Sediment Delivery Ratio (S_d)

The sediment delivery ratio (S_d) involves that portion of eroded sediment (gross sediment load) that is delivered to a stream. There are several factors that affect S_d. These include proximity of sediment sources from the stream; size, texture and density of sediment; velocity and volume of water discharge; terrain; and availability of deposition areas (e.g., valleys). There is no established formula to estimate S_d. However, the following equation for construction site derived empirically could be used (McElroy et al. 1976).

$$S_d = D^{-0.22} \tag{8}$$

where S_d = sediment delivery ratio
D = overland distance between the erosion site and the receptor water, in ft

Eq. 8 can be used for intensely disturbed areas such as mines, construction sites, fishponds, filling ponds and built-up areas. The D is usually between 0 and 250 m (800 ft).

For general croplands and forestlands, the S_d is determined using drainage density and soil type (McElroy et. al 1976). Essentially, the S_d is related to the inverse of drainage density for relatively homogeneous basins. The reciprocal of drainage density (DD^{-1}) relates to the closeness of spacing of channels within the basin. The drainage density (DD) is determined as follow:

a. DD = total channel-segment lengths in km divided by the drainage area in km^2.

b. Digitize the river systems or tributaries found within each sub-basin.

c. Compute for the total area of each of the sub-basin.

d. Measure each river-segment length in each of the sub-basins and then sum all the values.

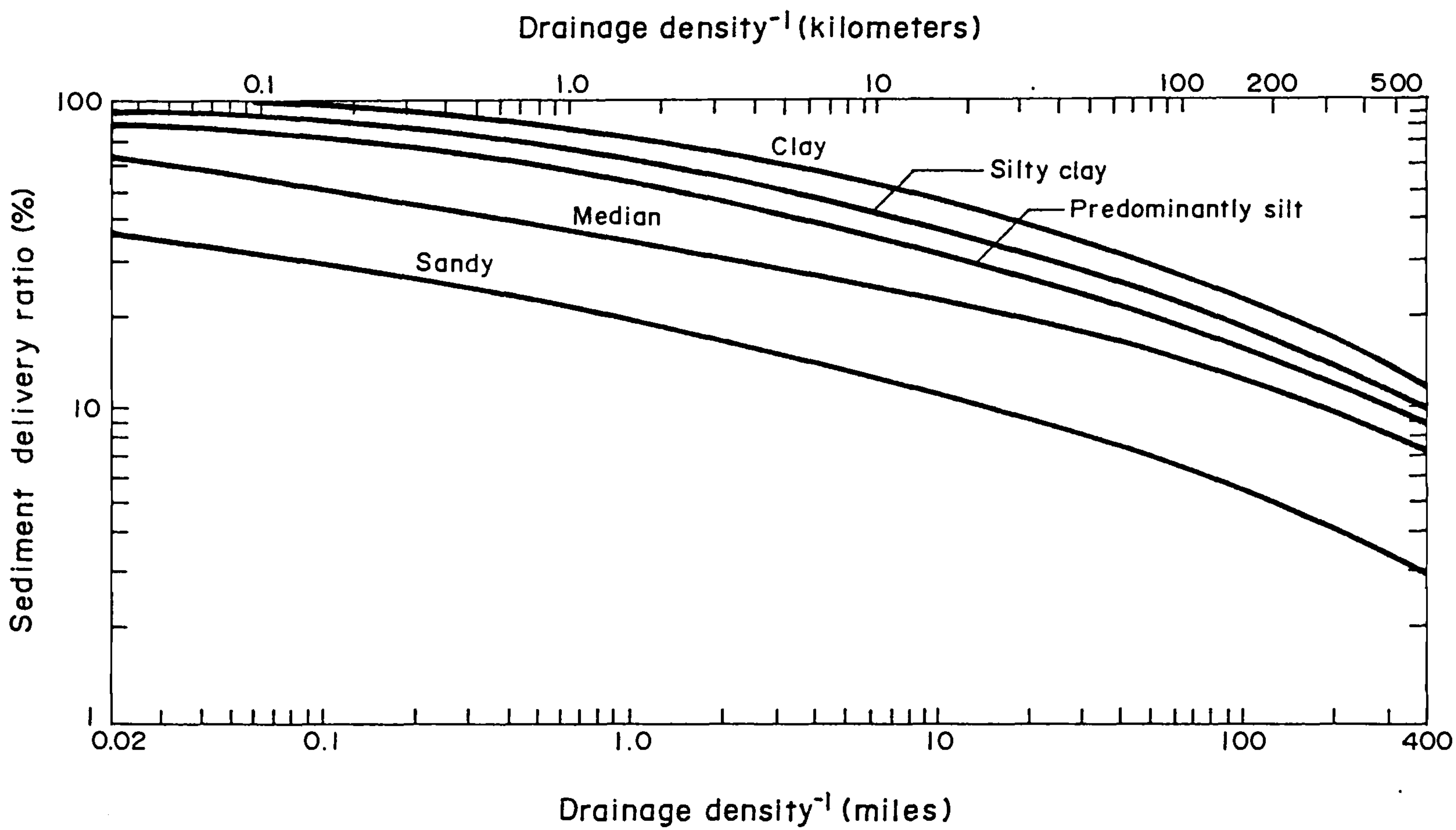
e. Divide the total river-segment lengths by the total sub-basin area to get DD. Then, divide DD by 1.

f. Determine the dominant soil type of the sub-basin.

g. Using the sediment delivery ratio graph, locate the position of the DD^{-1} of the sub-basin.

h. Move vertically and intersect with the appropriate soil texture, then move horizontally to the vertical axis to locate the S_d value for the sub-basin.

i. Generate a table of S_d for all sub-basins.


Drainage density^{-1} (kilometers)
0.1
1.0
10
100
200
500
Clay
Silty clay
Predominantly silt
Median
Sandy
Sediment delivery ratio (%)
100
10
1
0.02
0.1
1.0
10
100
400
Drainage density^{-1} (miles)

Sediment Yield Estimates

Annual sediment yield for each sub-basin is computed by multiplying the S_d with the sediment loss (Y) of the entire Agno River Basin:

$$Y(S)_E = \sum_{i=60}^{n} [A_{60}(Y \bullet S_d)_{60}] \tag{9}$$

where $Y = R \bullet K \bullet L \bullet S \bullet C \bullet P$

The $Y(S)_E$ should be adjusted to account for the presence of dams and other sediment trapping systems in the Agno Basin.

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Soil Erodibility Factor (K)

The soil erodibility factor (K) was computed per soil type based on per cent organic matter content. The K values were derived using the table reported by Mitchell and Bubenzer (1980). This table is used instead of a nomograph or using Eq. 4 as there were inadequate data on the physio-chemical characteristics of soils in the Agno River Basin. The values for K and % organic matter are averages of broad range of specific soil values.

With respect to the soil organic matter contents covering the four provinces (Benguet, La Union, Pangasinan and Tarlac), available quantitative values for specific soil types were not available. Most of the data were ordinal (high, moderate, low). However, even with such values, there is no standard system that is adapted by the Bureau of Soils and Water Management (BSWM). In the 5 Land Management Reports of BSWM, organic matter is variously categorized as follow:

Benguet	- no data
La Union	- adequate, marginal, low
Pangasinan	- medium, low, very low
Camarines Sur	- high, moderate, adequate
Tarlac	- no data

Quantitative values for organic matter content were reported for Tarlac, La Union and Pangasinan. However, only the La Union land management report had a quantitative equivalent as follows:

Organic Matter content (%)	Rating
> 3	Adequate
1-3	Marginal
<1	Deficient

Currently, BSWM uses the following categories:

Organic Matter content (%)	Rating
8-1	Adequate
	(Marginal)
<1	Deficient

The numerical equivalent of marginal is not included in the BSWM reports.

Under the United States Department of Agriculture (USDA) (Landon, eds. 1991), the organic matter contents converted from organic carbon values (x 1.72) are much higher:

Organic Matter content (%)	Rating
>34.4	Very high
17.2 - 34.4	high
6.88 - 17.2	medium
3.44 - 6.88	low
<3.44	very low

In the Agno River Basin, most of the quantitative values reported for organic matter fall below 4%. Organic matter content varies according to soil texture, landuse pattern and physiographic unit but the absence of such data presents a constraint towards accurately determining the K factor. In order to arrive at some estimate of K factor, several assumptions are made.

1. The rating on organic matter used in the La Union Land Management Report was adapted and adjusted to match the table of Mitchel and Bubenzer (1980).

2. The values of organic matter content from Mitchel and Bubenzer (1980) were giving some rating equivalent to BSWM system as follows:

Value	Rating (Adjusted)
<0.5 %	Deficient or very low
2.0 %	Low or marginal
4.0 %	High, moderate or medium

3. Although organic matter varies according to soil texture and physiographic unit, the absence of quantitative values for the study area makes it impossible to differentiate between differing physiographic units having the same soil texture. Therefore, the organic matter content for one soil type was assumed to be the same regardless of its physiographic characteristic.

4. Some of the soil texture types assigned to certain soils like undifferentiated mountain soils, rockland and complex were based the Land Management Project Reports (BSWM 1985a, b,c, d and 1987) wherein the location (with reference to soil maps) of the soils were matched with the physiographic units. The latter was described in some detail in the reports with corresponding information on soil texture and soil fertility parameters.

With the above assumptions, the following K factors have been generated for the Agno River Basin comprising four provinces:

Soil Texture	OM Content		K factor
Hydrosol (clay loam)	medium	4%	0.21
Loam	low	2%	0.34
Clay loam	medium	4%	0.21
Silty clay loam	medium	4%	0.26
Sandy clay loam	medium	4%	0.21
Gravel (silty) clay loam	medium	4%	0.26
Sandy loam	low	2%	0.24
Gravel (silt) loam	medium	4%	0.33
Silt loam	medium	4%	0.33
Sand	low	2%	0.03
Beach sand	low	2%	0.03
Clay	medium	4%	0.13
Mountain soils (clay)	medium	4%	0.13
Mountainous land (loam)	medium	4%	0.29
Gravel (silt)	medium	4%	0.42
Riverwash (siltloam)	low	2%	0.48
Complex (loam)	low	2%	0.34
Fine sand	low	2%	0.14
Fine sandy loam	medium	4%	0.16
Rockland (clay)	medium	4%	0.13
Undifferentiate soil of Tarlac (loam)	medium	4%	0.29

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Technical report PART II

Geographic Information System for Coastal Area Management and Planning Project

February 1994
ICLARM-IDRC-NEDA Region I

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Canada

Technical Report

on the

Geographic Information Systems

Application for Coastal Area

Management and Planning,

Lingayen Gulf Area, Philippines

Part II

Contents

Geographic Information Systems Applications for Coastal Area Management and Planning in the Lingayen Gulf Area, Philippines

Introduction

The provinces of Pangasinan and La Union border the 2,100 km^2 Lingayen Gulf in northwestern Luzon, Philippines. The area was the pilot site of the Association of Southeast Asian Nation/US Coastal Resource Management Program for its first regional attempt to promote integrated coastal area management (CAM). The output of the CRMP was a CAM plan aimed at the sustainable development of coastal resources in the Lingayen Gulf area. Significant multiple resource use conflicts pervade in the gulf area which the plan is trying to mitigate.

The completion of the CAM plan and its possible implementation by the National Economic and Development Authority Region I Office (NRO) will require substantial revision to respond to changes in the management area. This is particularly important in light of the current development thrust of the Philippine government to industrialize some areas in Region I and has not been adequately considered in the CAM plan. As such, information management, especially spatial data is needed in order to ensure timely formulation of management options for decision making and policy considerations relative to the development and management programs for the Lingayen Gulf area.

Geographic information systems (GIS) technology has been chosen as the most appropriate tool for spatial data management but this requires pilot testing to determine its suitability and relevance under local institutional setting. Thus. the Geographic Information Systems for CAM and Planning Project (GISCAMP) was implemented with the Lingayen Gulf area as the pilot site to address spatial data management as a complementary mechanism for efficient and timely utilization of information for decision making. The GISCAMP was a 2-year project (September 1991 - February 1994) funded by IDRC with ICLARM as the executing agency.

Rationale and Objectives

One of the recommended strategies of the CAM plan for the Lingayen Gulf is the development of a zonation scheme for both land use and water space utilization. On a broader context, the zonation scheme should consider the downstream impact of hinterland activities so that appropriate management options and policy actions can be formulated to deal with linked habitats such as

forests. Indeed, the CAM plan has addressed such issue with a proposal to rehabilitate the Upper Agno River System watershed (NEDA Region I 1992). The Agno River Basin largely drains into the Lingayen Gulf. Studies on the basin however, have been largely focused on water resource assessment for development purpose with very minimal consideration on the ecological aspect, particularly on the management and conservation of forests. In order to determine what actions to undertake with respect to the rehabilitation of the watershed, it is necessary to quantify the downstream impact of watershed activities such as land use changes in the basin and sediment yield. Thus, critical areas can be determined for rehabilitation activities.

The zonation scheme proposed in the CAM plan is essentially based on ecological and resource management considerations but more focus on the coastal waters component such aquaculture, mangrove rehabilitation, fisheries and marine critical habitats. The terrestrial component such as agriculture, forest land, industrial areas and tourism sites is not well defined. Impacts of development activities, both short- and long-term, for tourism, agriculture, industrialization and urban expansion remain to be assessed and incorporated into the zonation scheme.

The original objectives of the GISCAMP essentially emphasized on all aspects related to zonation but without considering a comprehensive zonation scheme and the impact of development pressures. In light of the recommendations of the CAM plan and recent development programs for the Lingayen Gulf area, the original objectives with respect to the application of GIS for CAM are modified to include a comprehensive zonation in the context of a 6-year development program.

Objectives

1. To evaluate coastal land use changes and marine space utilization with respect to fishing, commercial fry collection, marine parks, mangrove reforestation, aquaculture development, tourism, human settlements and artificial reef sites and their impacts using GIS.

2. To determine the sphere of influence of upland watershed activities in terms of sediment and pollutant influx into coastal areas and their impacts thereof using GIS.

3. To differentiate between natural and anthropogenic changes in the coastal zone, where possible, to pinpoint areas of intense human activities so that appropriate management guidelines can be instituted and to delineate areas for conservation.

4. To develop a zonation scheme for the Lingayen Gulf areas that is consistent with the principles of sustainable development.

5. To establish a databank on spatial and attribute information relevant to CAM and planning at the pilot site.

Methodology

To meet the above objectives, the terrestrial and water components are divided into sectors represented as activities. There are 9 activities with Activity 9 as the integration of Activities 1 to 8 and the development programs for the Lingayen Gulf. The 9 activities are:

Activity 1	*Impact of upland watershed and lowland land use activities on the coastal zone.*
Activity 2	*Impact of human settlement development and expansion on the coastal area.*
Activity 3	*Delineation of fishing zones in Lingayen Gulf.*
Activity 4	*Delineation of fry grounds in Lingayen Gulf.*
Activity 5	*Identification and assessment of marine park and artificial reef zones.*
Activity 6	*Identification and assessment of coastal tourism areas.*
Activity 7	*Identification and assessment of mangrove reforestation areas.*
Activity 8	*Identification and assessment of areas for aquaculture development.*
Activity 9	*Zonation scheme for the coastal zone of Lingayen Gulf.*

Specific GIS procedures are designed for each activity using a GIS software called Spatial Analysis System (SPANS) developed by INTERA TYDAC Technologies of Canada (Version 5.22) for PC microcomputer. Spreadsheets, text editors and database management system (DBMS) are used for processing and analysis of attribute information prior to importation into the GIS. Remotely sensed data (March 1990 Landsat Thematic Mapper) were used to update topographic and thematic maps. Rectification was done by the National Mapping and Resource Information Authority (NAMRIA) using microBrian, an application based image processing system developed by CSIRO and MPA International Pty Ltd of Australia. Ground truthing using Global Positioning System was conducted by the project staff and some information on coral reef

cover was provided by the Marine Science Institute of the University of the Philippines. Photo interpretation of aerial photographs was also conducted by NAMRIA.

To facilitate GIS analysis, each activity follows a standard procedure:

1. Specific objective - defines an objective where GIS can be applied.

2. Information and data needs - define what data are needed in doing the GIS analysis and in what format the data should be collected and processed

3. Flow of processing tasks - define the transformation of data for GIS analysis and the GIS functions to execute in order to meet the objective.

Information and data needs are of two types - map and attribute data. Maps include topographic maps, nautical charts and thematic maps (e.g., soils, slopes, physiography) as well as remote sensed data. Maps including the aerial photographs are digitized using the digitizing package of SPANS called TYDIG (Version 4.3) while remotely sensed data are in digital format imported into SPANS as raster (grid) files. Digitizing was done using a 24" x 36" CALCOMP drawing board II model 33360 with 16 button cursor. Attribute data like population data, number of fishing boats and rainfall data, etc. are encoded in spreadsheets and DBMS following SPANS format and imported as table files. Many of the attribute data collected have to undergo preprocessing to ensure data consistency, detect and correct errors, aggregation and resampling. The latter are for large datasets. Most of the attribute data are point data. Point data are processed in SPANS either as surface maps, point maps or maps with some zone of influence/interest using the buffer function. These various map layers are then overlaid according to specific objectives according to the procedure enumerated above.

Impact of Human Settlement Development and Expansion on the Coastal Area

Agnes G. A.. Cargamento[1]
Nestor G. Rillon[1]

Abstract

The provinces of Pangasinan and La Union are considered economic growth centers in Region I. Thrust of the government towards industrialization of the region will have significant impact on the economy and demography of two provinces, especially Pangasinan. Over the span of 30 years, many rural areas within the vicinity of urban centers have been upgraded into urban status. The study assesses land conversion relative to urban expansion as well as identifies potential area for settlement expansion in the context of a medium-term development program.

INTRODUCTION

The provinces of Pangasinan and La Union are considered relatively advanced compared to the other provinces in Region I because of the relatively higher number and distribution of infrastructures and utilities, employment opportunities - both in agriculture and industry - social services and facilities. These two provinces account for almost three fourths of the region's population, with a sizeable portion concentrated in the coastal municipalities bordering the Lingayen Gulf.

Under the 1993-1998 Medium Term Regional Development Plan (MTRDP), these two provinces, particularly the coastal municipalities within the Gulf, are expected to play a significant developmental role as the region's primary growth hub. Particularly under the Northwestern Luzon Growth Quadrangle Program which is envisioned as the MTRDP's major implementing strategy, this area will be the site for three of the industrial centers to be developed. Too, the Lingayen Gulf area will continue to be the region's major fishing ground, as well as tourist destination. These planned developments are expected to result in more people moving into the area, exerting more pressure

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into the coastal resources in terms of resource extraction/utilization and environmental pollution. As such, these development thrusts require the efficient and equitable utilization of the terrestrial and marine resources to ensure sustainable development.

In anticipation of these developments, it is therefore necessary to look at the current as well as past settlement patterns within the area and how these have affected land uses therein as basis for projecting the future direction of settlement expansion and the land use changes this will entail. This study documents and assesses land use changes with respect to settlement expansion in the Lingayen Gulf coastal area with the use of GIS. The study's more specific objectives are:

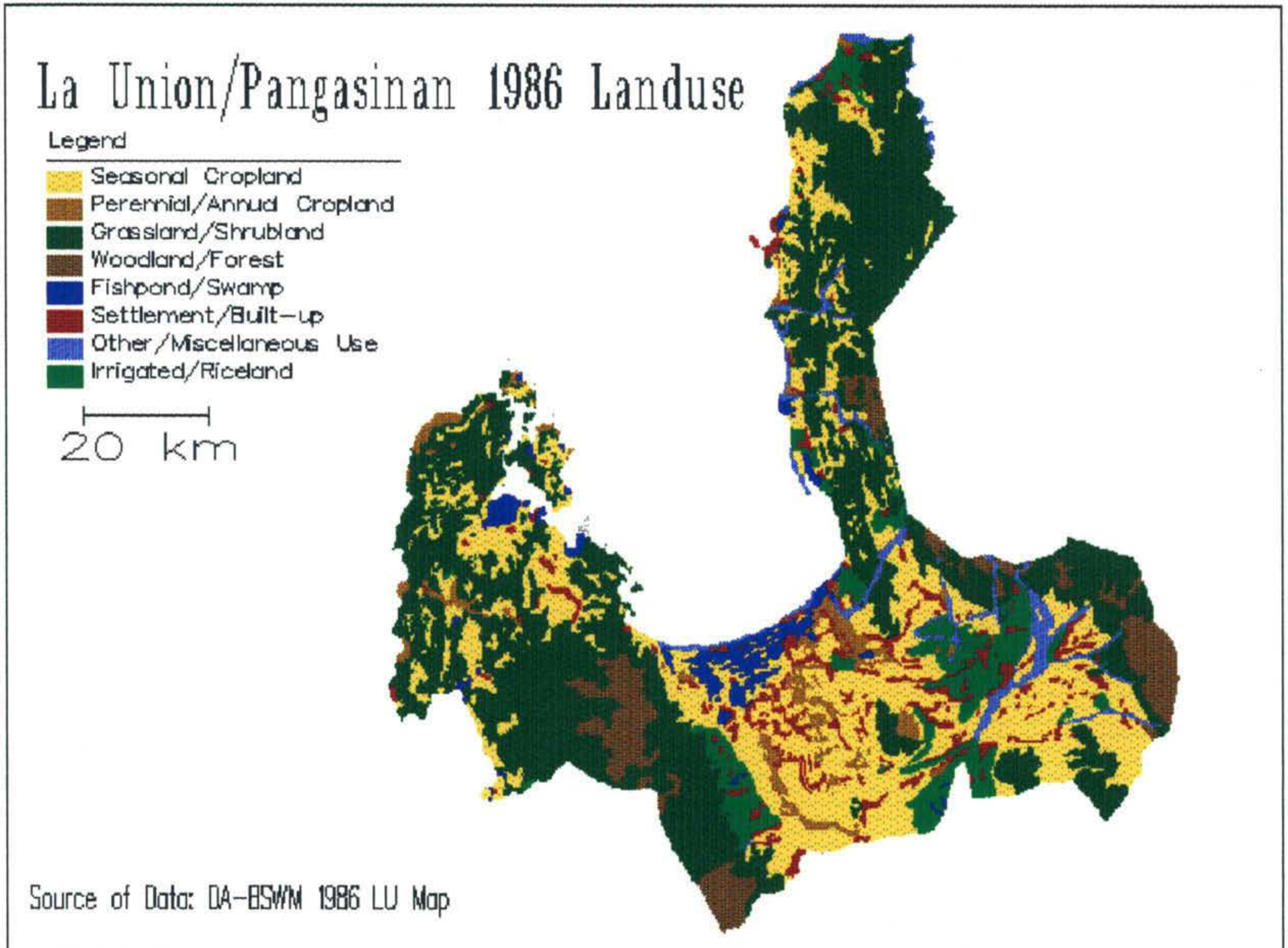
1. to document the urban expansion through land use changes and road infrastructure improvement;
2. assess population density changes at the barangay and municipal levels as an indication of urbanization, and
3. determine the direction of settlement expansion in terms of proximity to existing urban centers and road infrastructure.

METHODOLOGY

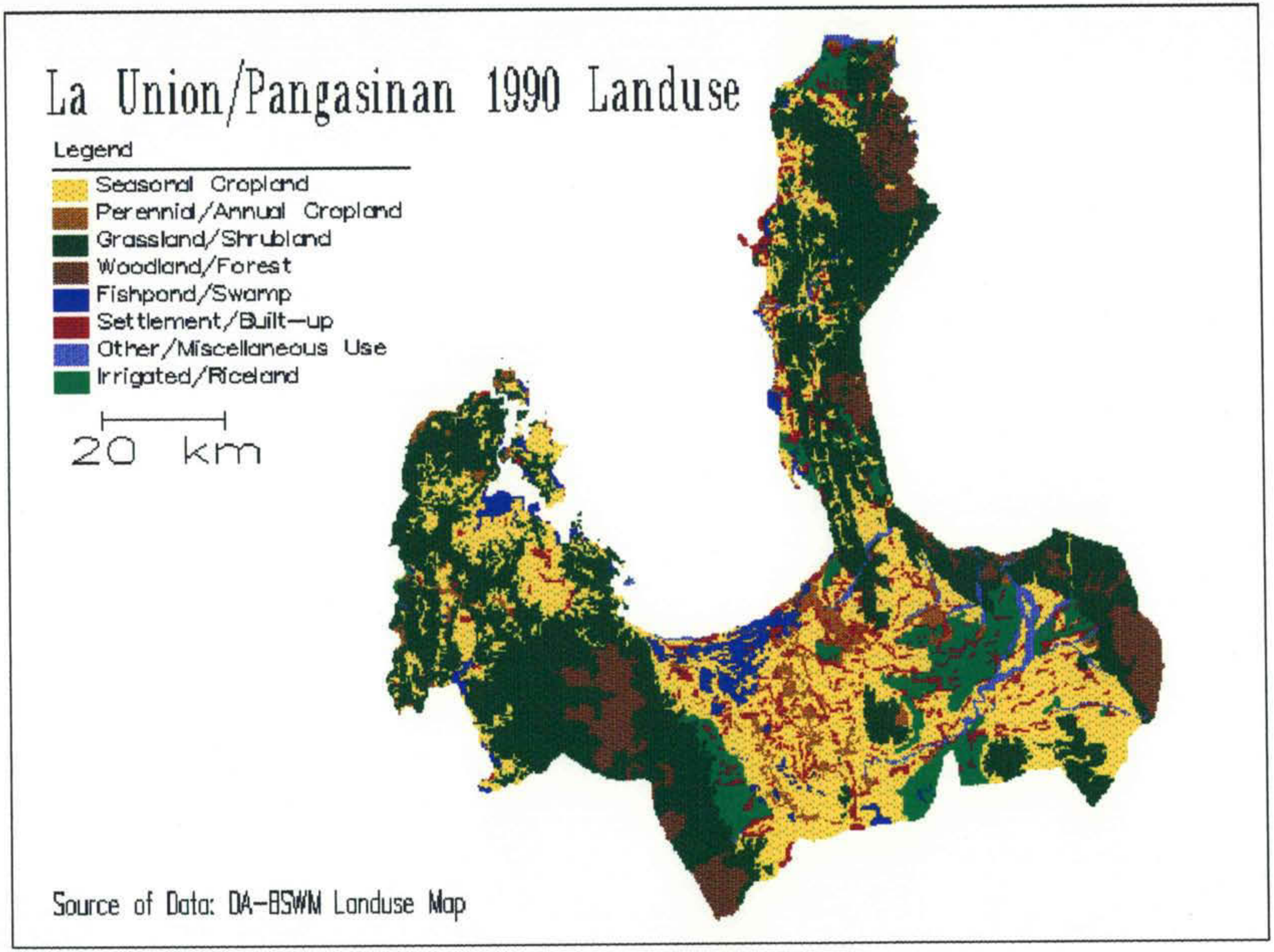
The activity used geographic information system software called Spatial Analysis System (SPANS) Version 5.22 for analysis of spatial data, spreadsheet and word processor were used for attribute data capture and manipulation.

Documentation of Urban Expansion Through Land Use Change

The 1986 and 1990 land use maps of both province were digitized using maps from the Bureau of Soils and Water Management. The original 59 map classes were consolidated into 8 general classes as follows: seasonal cropland, perennial/annual cropland, grassland/shrubland, woodland/ forest, fishpond/swamp, settlement/built-up, other miscellaneous uses (including rivers, riverwash, etc.), and irrigated riceland. The specific uses for fishpond and irrigated ricelands have been highlighted in view of the prohibitions from conversion imposed by law.



La Union/Pangasinan 1986 Landuse
Legend
Seasonal Cropland
Perennial/Annual Cropland
Grassland/Shrubland
Woodland/Forest
Fishpond/Swamp
Settlement/Built-up
Other/Miscellaneous Use
Irrigated/Riceland
20 km
Source of Data: DA-BSWM 1986 LU Map


La Union/Pangasinan 1990 Landuse
Legend
Seasonal Cropland
Perennial/Annual Cropland
Grassland/Shrubland
Woodland/Forest
Fishpond/Swamp
Settlement/Built-up
Other/Miscellaneous Use
Irrigated/Riceland
20 km
Source of Data: DA-BSWM Landuse Map

To determine land conversion for settlement/built-up use, the 1990 map was further transformed to reflect only the built-up/settlements areas. The two maps were overlaid to reflect from which of the 8 classes in the 1986 land use map built-up or settlements areas in the 1990 land use map were generated. Area analysis was also performed to generate the size of the change in land use.

Assessment of Population Change at Barangay and Municipal Level

The municipal and barangay maps of the study area were generated through digitization of cadastral maps from the Lands Management Sector of the Department of Environment and Natural Resources.

Barangay population data for the censal years 1975, 1980 and 1990 were appended to the barangay map generating the barangay population maps for each of the censal years. Population density was also appended at the barangay level for each censal year.

Determination of the direction of expansion in terms of proximity to existing urban centers and road infrastructure.

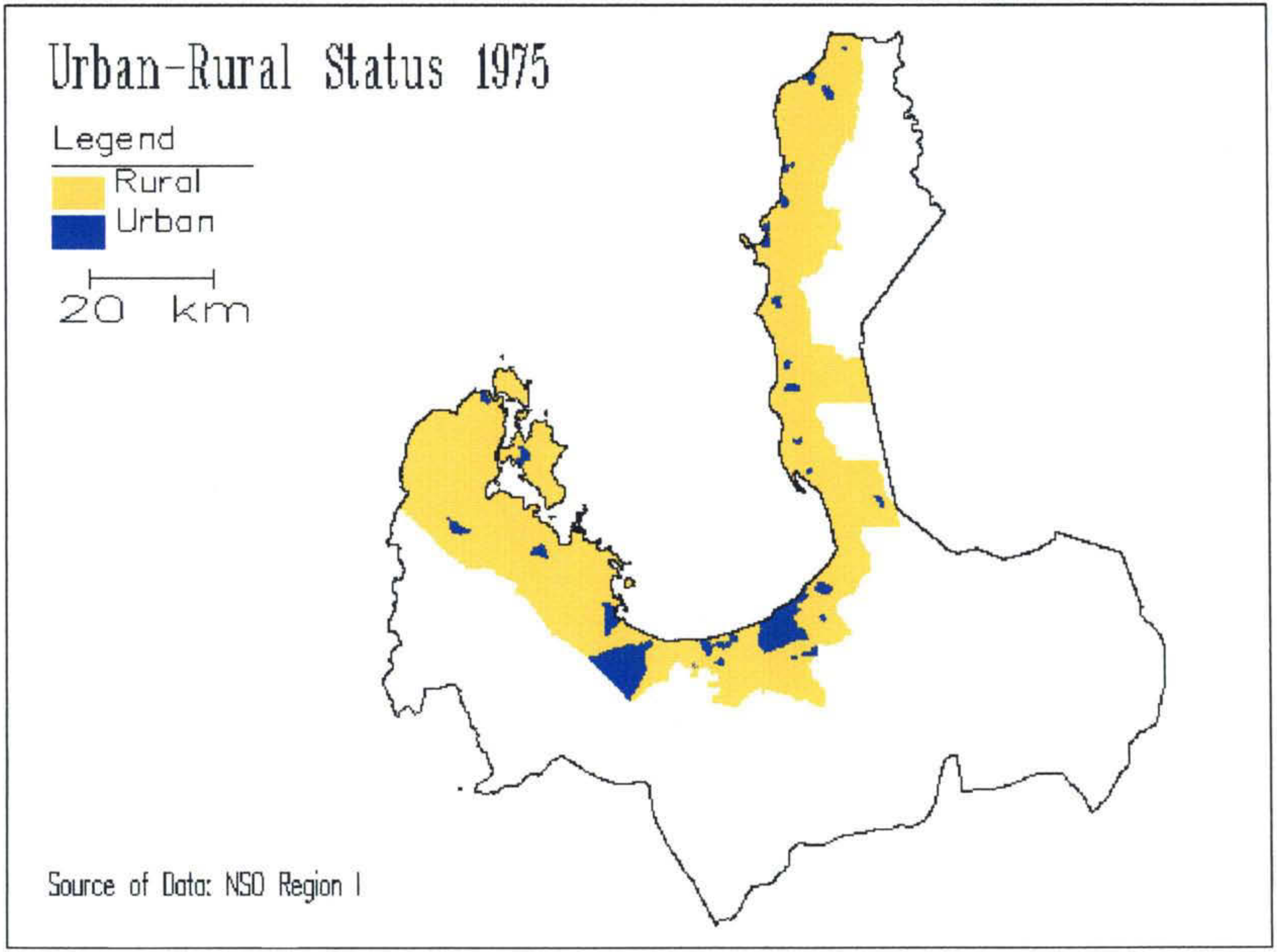
Urban-rural status map based on the National Statistics Office classification, was generated for each of the censal years. Through the overlaying process, the change in urban-rural status and status change from 1975 to 1980 and 1980 to 1990 were determined.

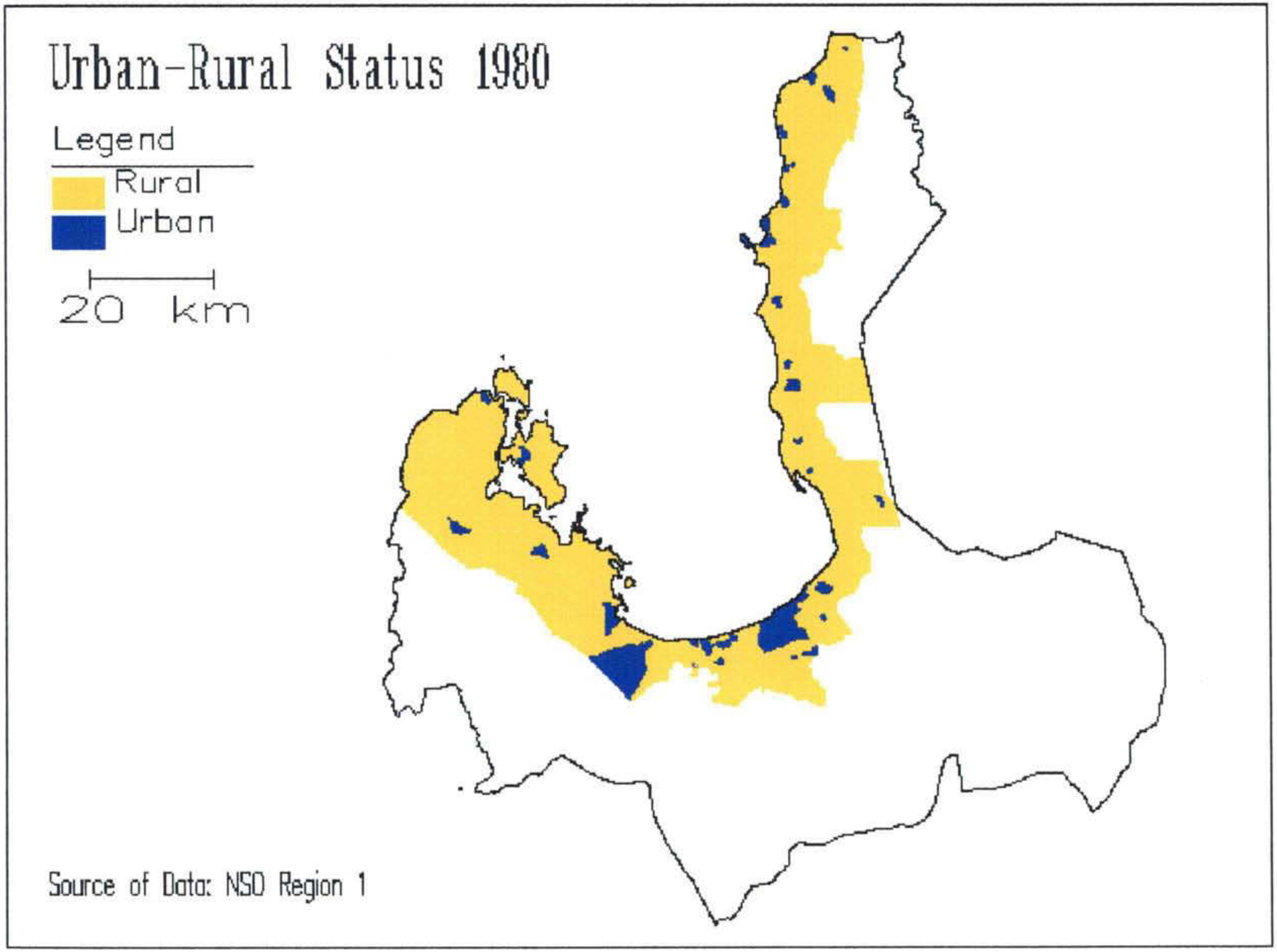
Areas classified by urban-rural status and population density and located within 1 and 2 kilometers of national and provincial roads were identified using the modelling features of SPANS. The resultant together with the slope map, land use map, map delineating the distance from the shoreline and river's were used as criteria maps in identifying potential areas for settlements expansion.

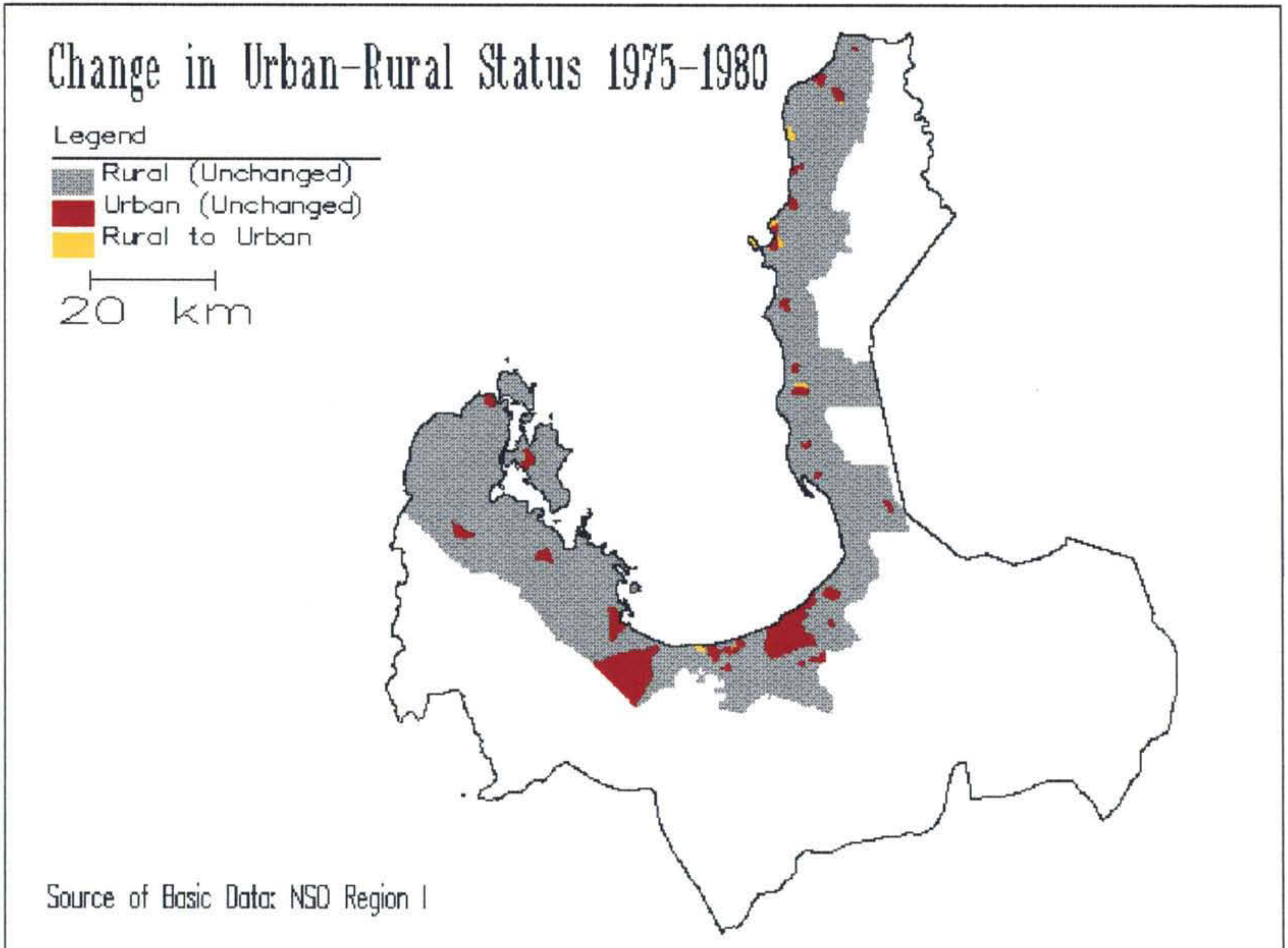
RESULTS AND DISCUSSION

Documentation of Urban Expansion through Land Use Changes

Over the 4 year period from 1986 to 1990, the settlement/built-up areas within the municipalities in the Lingayen Gulf increased from 93 km^2 to 117.88 km^2. Around one third of the area expansion came from seasonal croplands. Almost 20% of the built-up areas in 1990 were from conversion occurring in environmentally critical areas (as identified in Presidential Decree No. 1586) in fishponds/swamps (including mangroves) and prime agricultural or irrigated ricelands. This is indicative of violations on existing laws prohibiting


Urban-Rural Status 1975
Legend
Rural
Urban
20 km
Source of Data: NSO Region I


Urban-Rural Status 1980
Legend
Rural
Urban
20 km
Source of Data: NSO Region 1


Change in Urban-Rural Status 1975-1980
Legend
Rural (Unchanged)
Urban (Unchanged)
Rural to Urban
20 km
Source of Basic Data: NSO Region I

conversions or defining exclusion zones for settlement expansion.

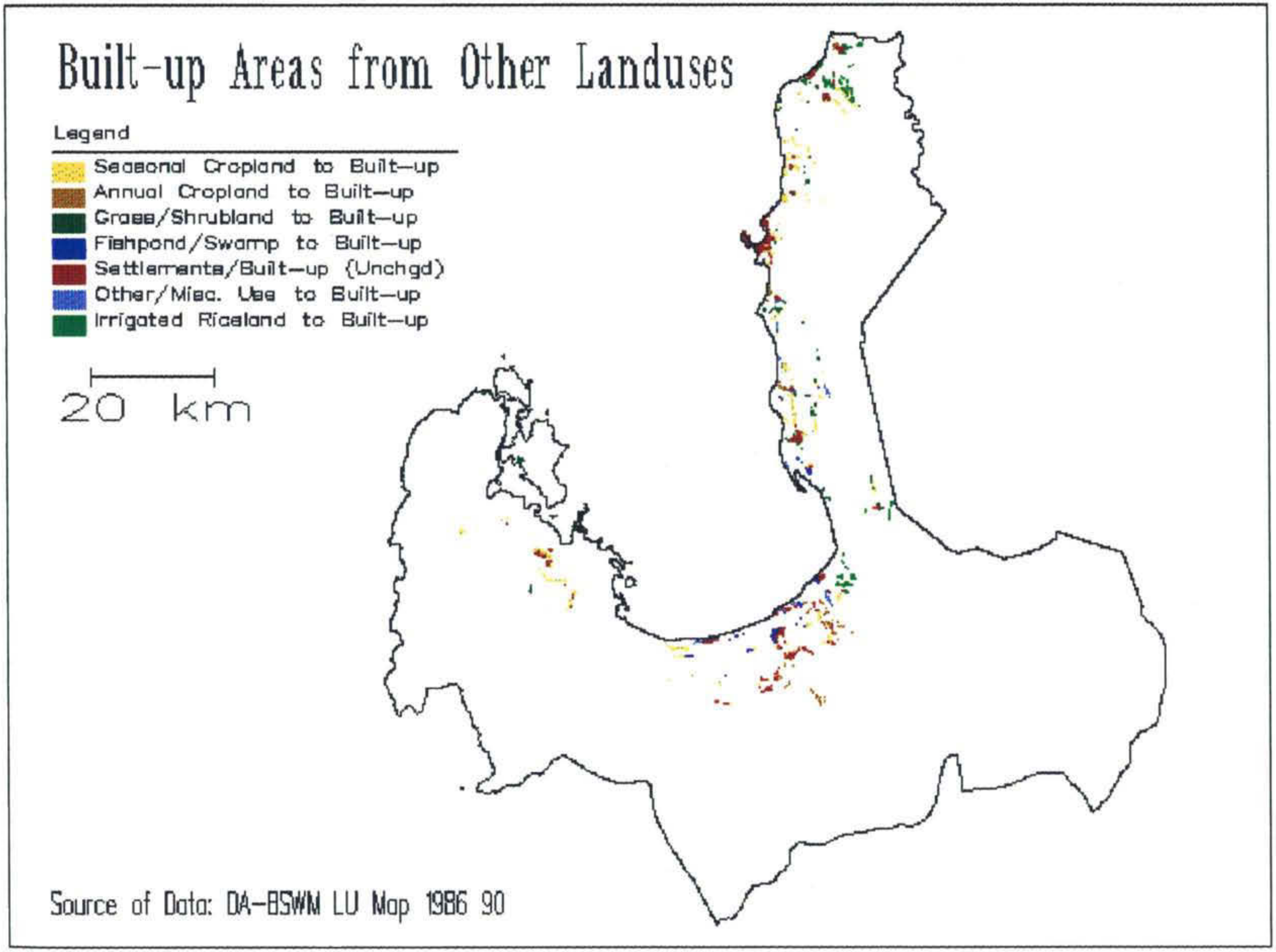
Table 1. Sources of Change in Settlement/Built-up Areas by Land Use (1986-1990)

Former Land Use of Existing Built-up Area	Area (km^2)	Area (%)
Seasonal Cropland	35.732	30.31
Annual Cropland	9.292	7.88
Grass/Shrubland	10.890	9.24
Fishpond/Swamp	7.350	6.23
Settlements/Built-up	34.597	29.35
Other/Misc. Use	7.678	6.51
Irrigated Riceland	12.339	10.47
TOTAL	117.878	100.00

Assessment of Population Change at Barangay and Municipal Level

Over the 15-year period from 1975 to 1990, the number of barangays with population density of 500 and below has declined. In terms of area, there has been a decline from 77% in 1975 to 69% in 1990.

It can be gleaned from the following table that the areas with population ranging from 1,000 to 4,000 has increased from 39% in 1975 to 56% in 1990. These changes in the concentration of population should be considered in determining the viability of providing and locating required settlement services and functions or assessing the feasibility of putting up required infrastructures and industrial centers.



Built-up Areas from Other Landuses
Legend
Seasonal Cropland to Built-up
Annual Cropland to Built-up
Grass/Shrubland to Built-up
Fishpond/Swamp to Built-up
Settlements/Built-up (Unchgd)
Other/Misc. Use to Built-up
Irrigated Riceland to Built-up
20 km
Source of Data: DA-BSWM LU Map 1986 90

Table 2. Barangay Population 1975, 1980 and 1990

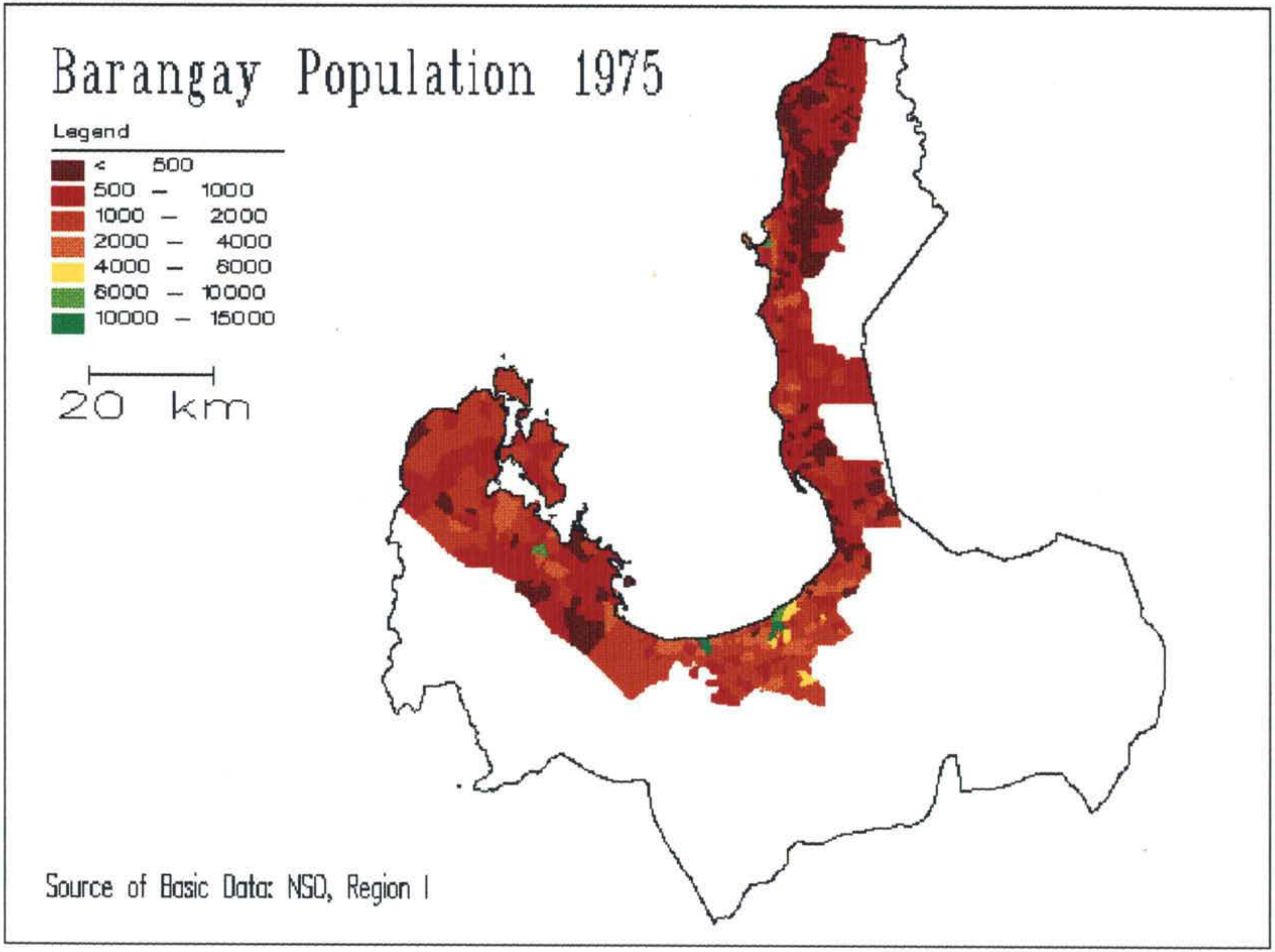
Population	1975		1980		1990	
	Area (%)	Area (km^2)	Area (%)	Area (km^2)	Area (%)	Area (km^2)
< 500	15.43	307.35	11.86	236.29	8.46	168.58
500- 1,000	43.24	861.42	41.58	828.49	31.68	631.13
1,000- 2,000	32.27	642.93	34.18	680.92	40.77	812.22
2,000- 4,000	7.41	147.63	10.21	203.43	15.50	308.77
4,000- 6,000	0.81	16.13	1.32	26.26	2.18	43.34
6,000-10,000	0.49	9.69	0.34	6.77	0.91	18.12
10,000-15,000	0.36	7.16	0.51	10.16	0.51	10.16
TOTAL	100.00	1,992.32	100.00	1,992.32	100.00	1,992.32

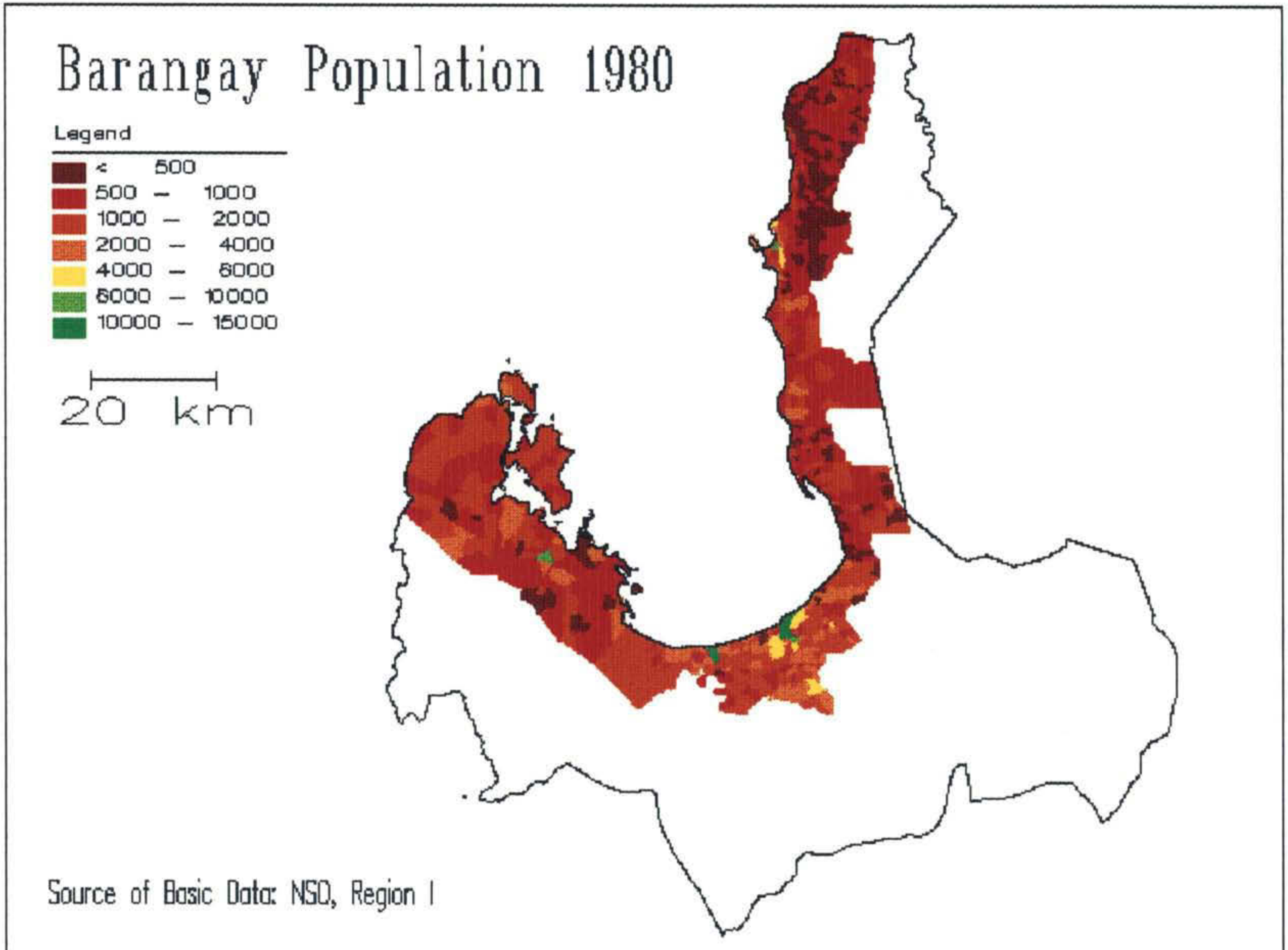
Table 3. Barangay Population Density 1975, 1980 and 1990

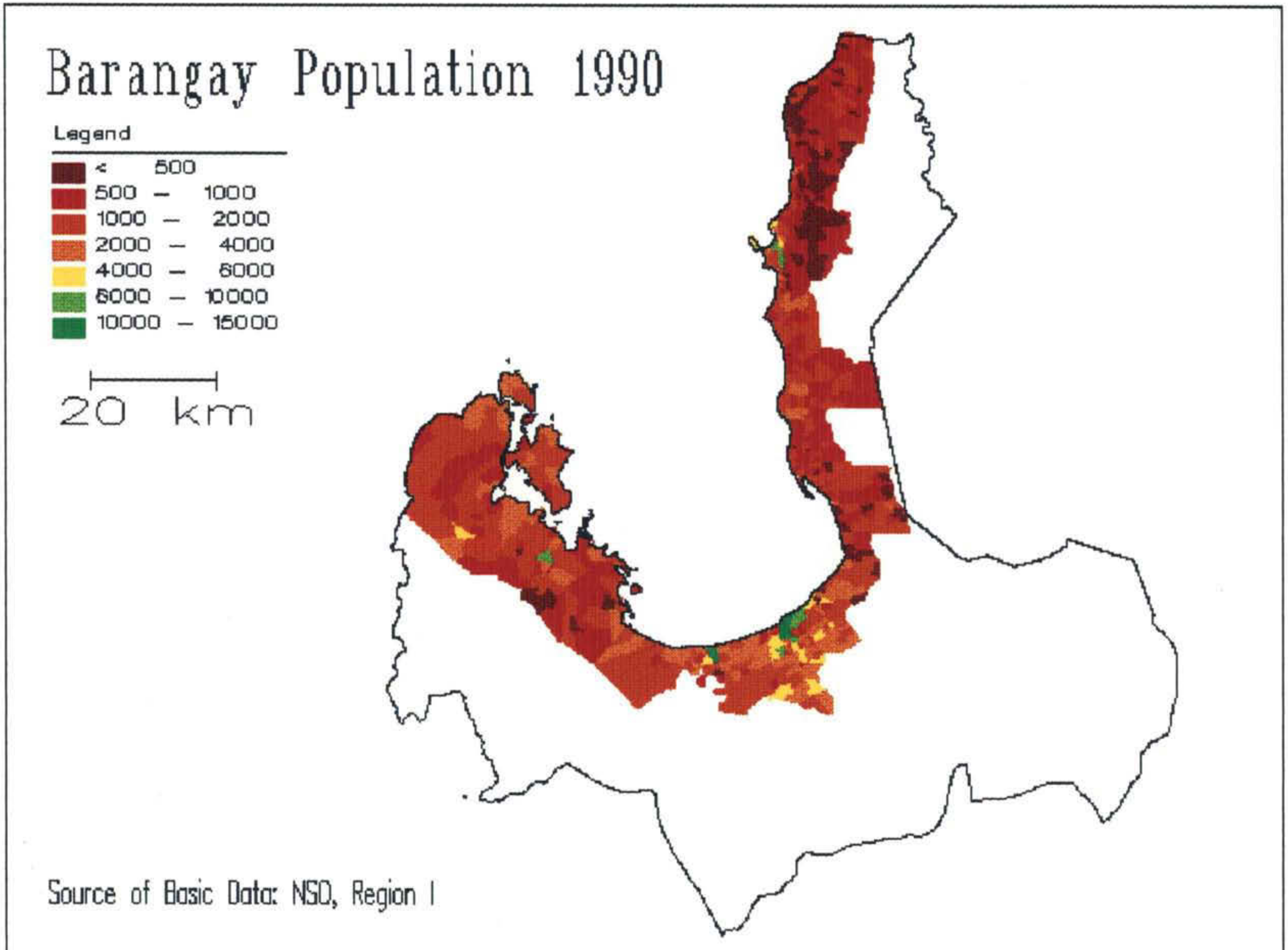
Population Density	1975 Area (%)	Area (km^2)	1980 Area (%)	Area (km^2)	1990 Area (%)	Area (km^2)
500 and Below	76.60	1,525.76	74.00	1,474.00	69.01	1374.59
More than 500	23.40	466.08	26.00	517.84	30.99	617.25
	100.00	1,991.85	100.00	1,991.85	100.00	1,991.85

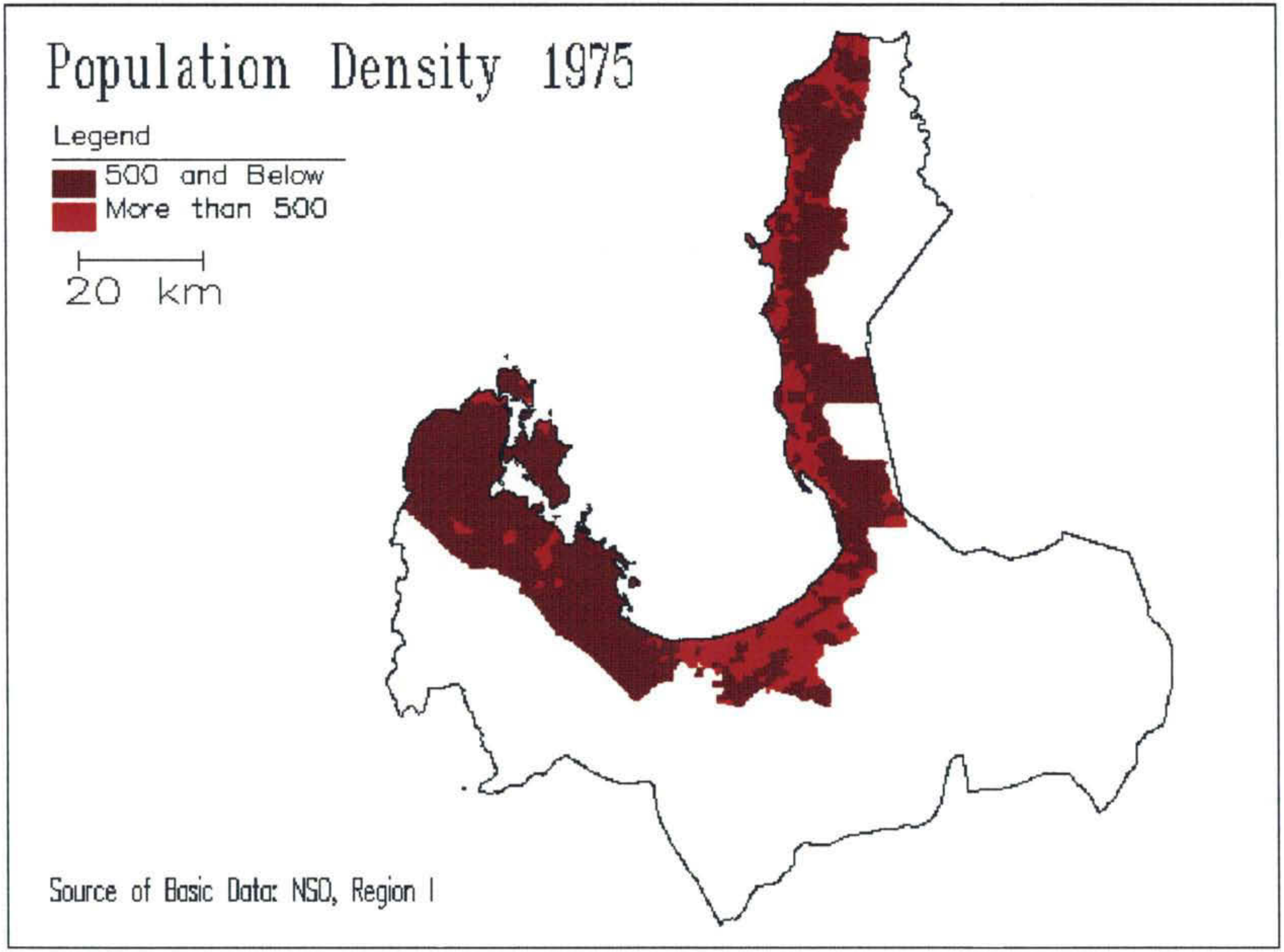
Determination of the direction of expansion in terms of proximity to existing urban centers and infrastructure.

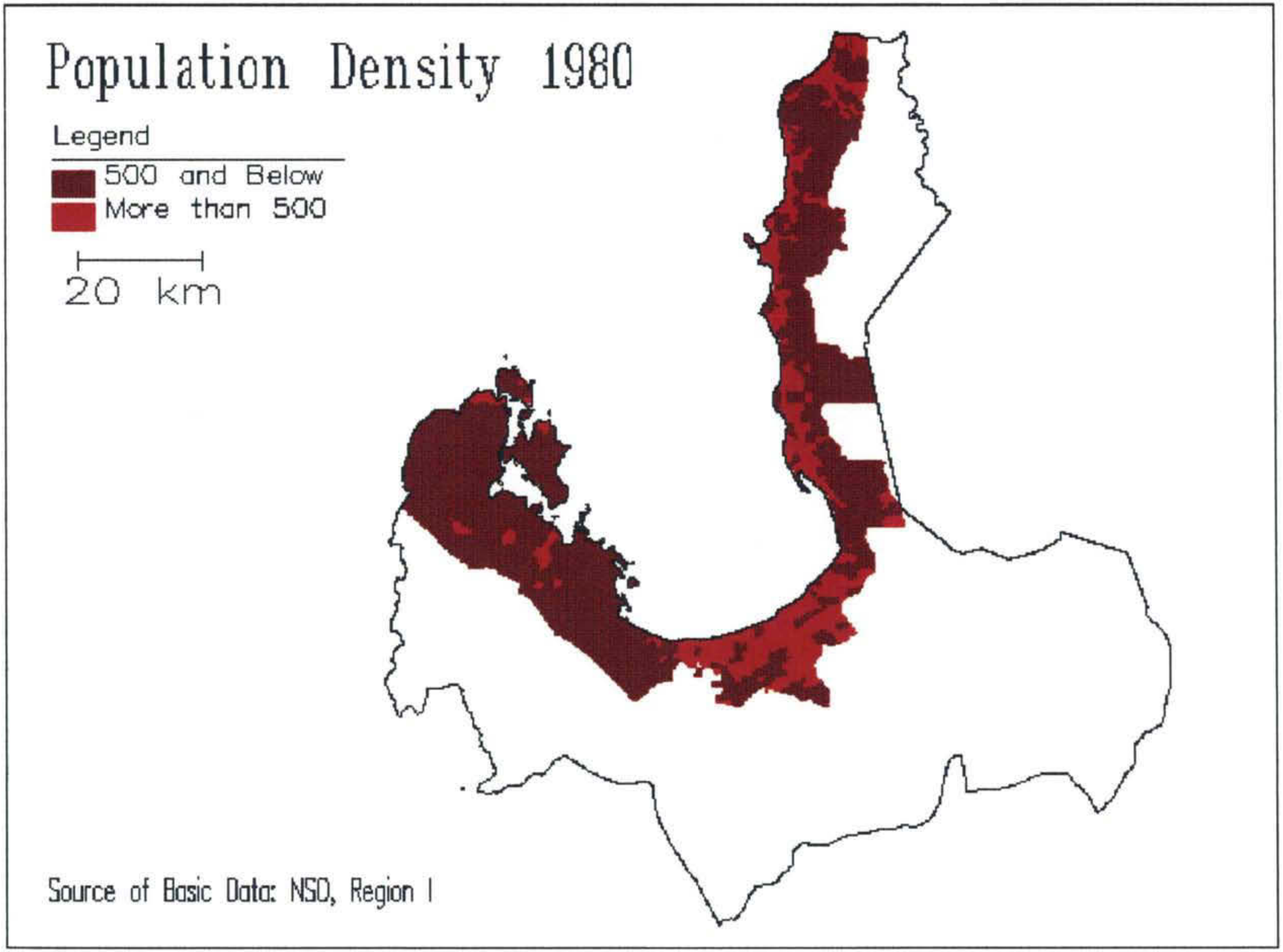
The determination of land suitable for settlement/ built-up area expansion entailed the analysis of the physical characteristics (such as slope) of the area as well as some economic aspects as may be deduced from specific barangay densities (i.e., a rural barangay with density higher than 500 is deemed to have a greater potential for urban expansion from the standpoint of cost of extending basic services and facilities).

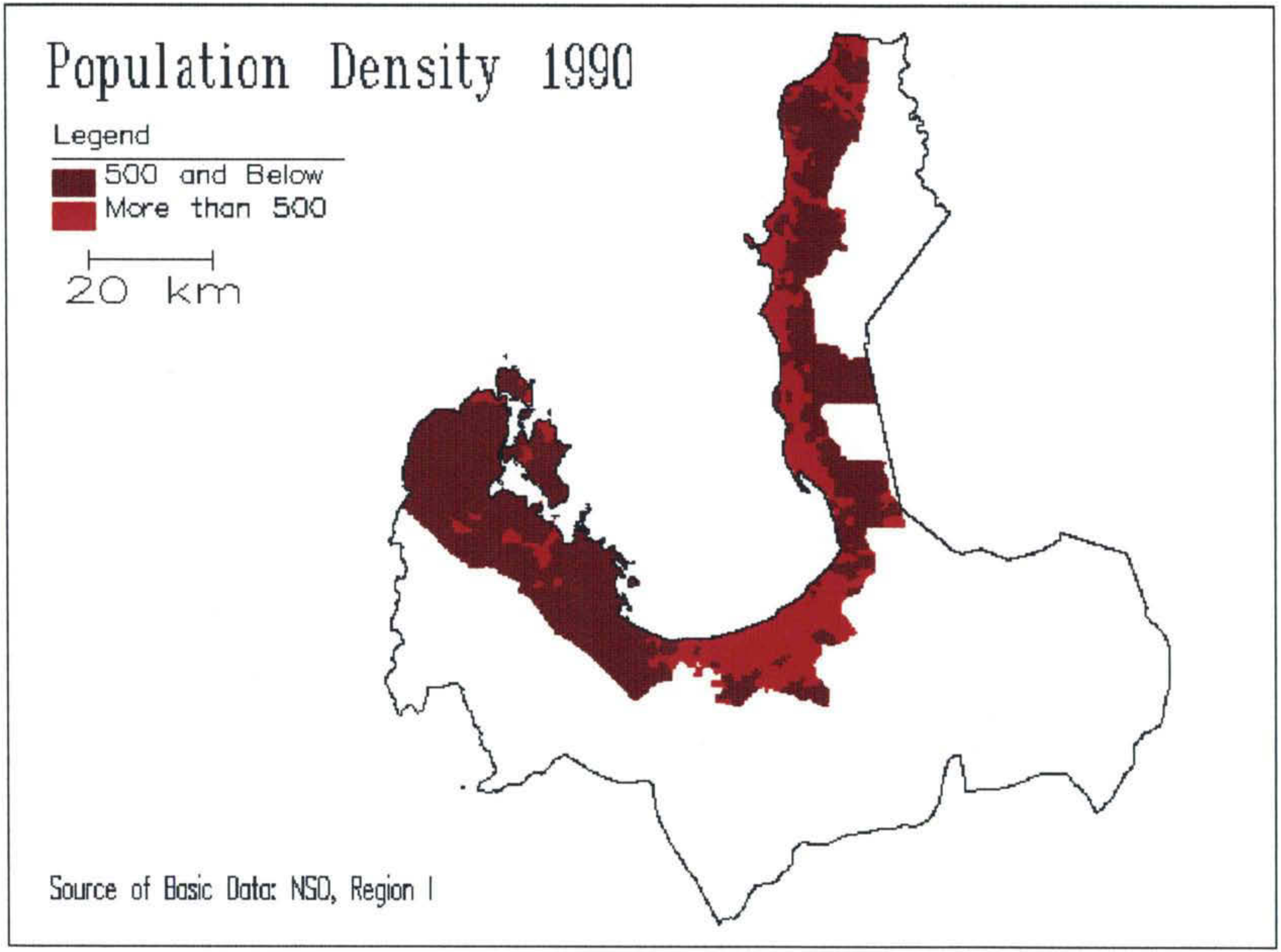

Barangay Population 1975
Legend
< 500
500 – 1000
1000 – 2000
2000 – 4000
4000 – 6000
6000 – 10000
10000 – 15000
20 km
Source of Basic Data: NSO, Region I


Barangay Population 1980
Legend
< 500
500 – 1000
1000 – 2000
2000 – 4000
4000 – 6000
6000 – 10000
10000 – 15000
20 km
Source of Basic Data: NSO, Region I


Barangay Population 1990
Legend
< 500
500 – 1000
1000 – 2000
2000 – 4000
4000 – 6000
6000 – 10000
10000 – 15000
20 km
Source of Basic Data: NSO, Region I


Population Density 1975
Legend
500 and Below
More than 500
20 km
Source of Basic Data: NSO, Region I


Population Density 1980
Legend
500 and Below
More than 500
20 km
Source of Basic Data: NSO, Region I


Population Density 1990
Legend
500 and Below
More than 500
20 km
Source of Basic Data: NSO, Region I

In the whole study area, about 9% are deemed suitable for settlement expansion, about 15% fairly suitable and about 76 % are deemed not suitable for settlement expansion. In terms of location, the most suitable areas for expansion are along the San Fernando-Bauang stretch in La Union and in San Fabian in Pangasinan. These suitable areas are currently used as croplands. There are around 18 km^2 classified as suitable expansion areas which are currently used as irrigated ricelands or fishponds. Owing to the environmental sensitivity of these areas, their conversion into settlement expansion should be resorted to only when necessary and unavoidable and with the appropriate conservation and management measures in order not to destroy adjacent areas.

Table 4. Land Area of Potential Areas for Settlements Expansion

Legend	Area (%)	Area (km^2)
Most Suitable	0.25	4.97
Suitable	8.85	176.59
Fairly Suitable	14.92	297.60
Not Suitable	75.98	1,515.82
TOTAL	100.00	1,994.98

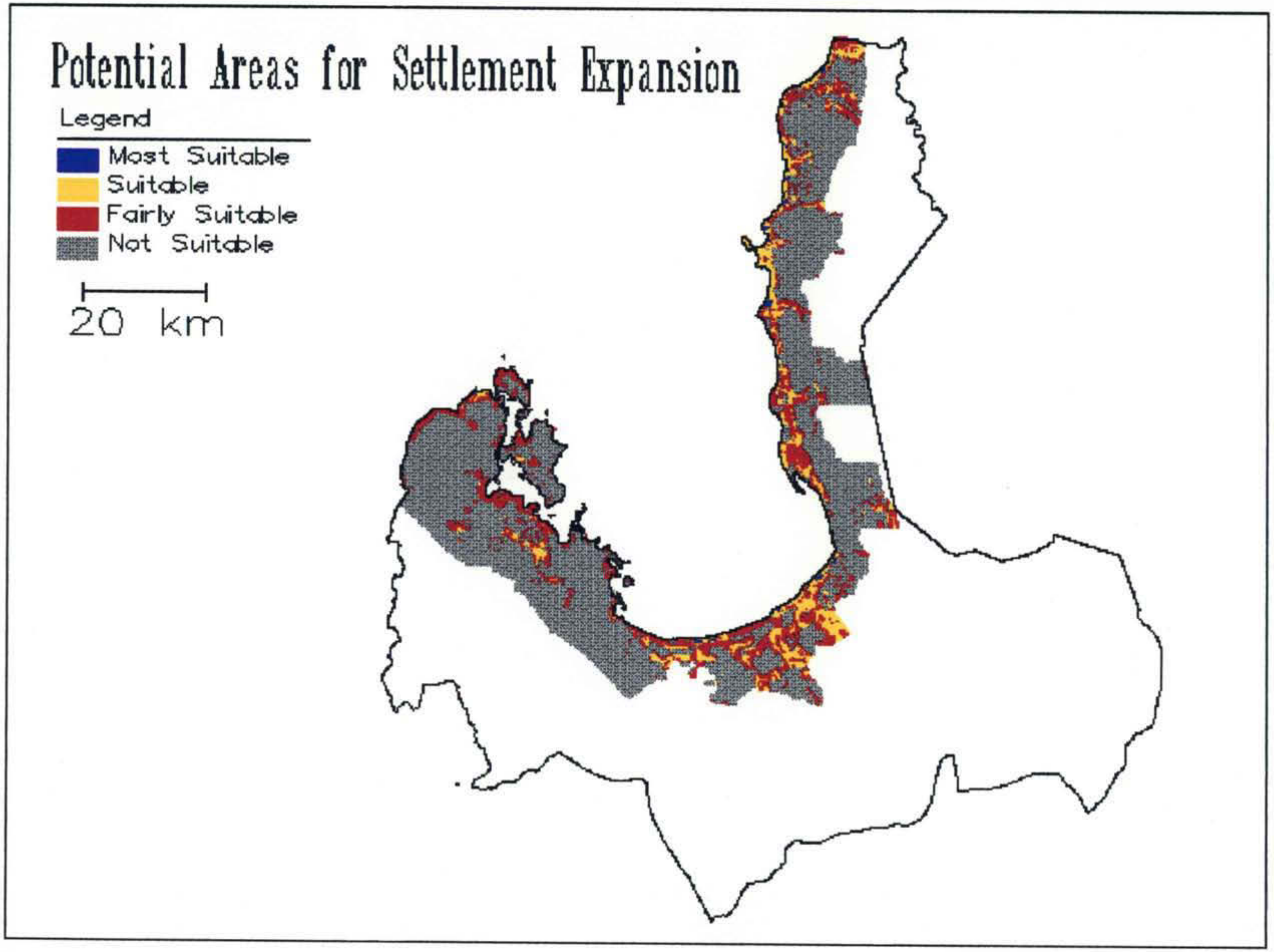

Potential Areas for Settlement Expansion
Legend
Most Suitable
Suitable
Fairly Suitable
Not Suitable
20 km

Table 5. Land Area of Potential Areas for Settlements Expansion by Kind of Land Use

	1	2	3	4	5	6	7	8	Total*
Area (km^2) Total % Row %									
Most Suitable									
	0.06	0.97	0.00	0.00	0.00	3.94	0.00	0.00	4.97
	0.00	0.05	0.00	0.00	0.00	0.20	0.00	0.00	0.25
	1.20	19.52	0.00	0.00	0.00	79.28	0.00	0.00	
Suitable									
	38.42	29.65	10.70	0.00	12.80	75.92	3.57	5.53	176.59
	1.93	1.49	0.54	0.00	0.64	3.81	0.18	0.28	8.85
	21.76	16.79	6.06	0.00	7.25	42.99	2.02	3.13	
Fairly Suitable									
	84.88	28.46	76.75	0.00	46.68	31.91	10.28	18.64	297.60
	4.26	1.43	3.85	0.00	2.34	1.60	0.52	0.93	14.92
	28.52	9.56	25.79	0.00	15.69	10.72	3.45	6.26	
Not Suitable									
	522.90	21.35	768.54	57.44	84.37	6.11	12.68	42.25	1,515.64
	26.21	1.07	38.53	2.88	4.23	0.31	0.64	2.12	75.98
	34.50	1.41	50.71	3.79	5.57	0.40	0.84	2.79	
Total									
	646.26	80.43	855.99	57.44	143.86	117.88	26.53	66.42	1,994.80
	32.40	4.03	42.91	2.88	7.21	5.91	1.33	3.33	

* Classes are the following 1) Seasonal cropland, 2) Perennial Cropland, 3) Grass/Shrubland, 4) Forest land, 5) Fishpond, 6) Built-up area, 7) Other and 8) Irrigated ricefields.

Table 6. Land Area of Potential Areas for Settlements Expansion by Slope Type

	0 - 3%	3 - 8%	8 - 15%	TOTAL
Most Suitable				
Area (km^2)	4.97	0.00	0.00	4.97
Total %	0.41	0.00	0.00	0.41
Row %	0.00	100.00	0.00	0.00
Suitable				
Area (km^2)	168.88	2.58	1.57	173.03
Total %	13.82	0.21	0.13	14.16
Row %	97.60	1.49	0.91	
Fairly Suitable				
Area (km^2)	247.50	23.00	6.69	277.19
Total %	20.25	1.88	0.55	22.68
Row %	89.29	8.30	2.41	
Not Suitable				
Area (km^2)	589.43	59.35	118.21	766.99
Total %	48.23	4.86	9.67	62.76
Row %	76.85	7.74	15.41	
Total	1,010.78	84.94	126.47	1,222.19
	82.70	6.95	10.35	

Table 7. Land Area of Potential Areas for Settlements Expansion by Urban-Rural Status, Population Density and Distance from National and Provincial Roads

1	2	3	4	5	6**	Total
Area (km^2) Total % Row %						
Most Suitable						
0.00	0.00	2.70	0.76	0.00	1.51	4.97
0.00	0.00	0.81	0.23	0.00	0.45	1.49
0.00	0.00	54.35	15.32	0.00	30.33	
Suitable						
1.75	0.11	103.60	17.22	3.82	26.98	153.48
0.52	0.03	30.99	5.15	1.14	8.07	45.92
1.14	0.07	67.50	11.22	2.49	17.58	
Fairly suitable						
1.23	0.70	57.83	46.95	9.20	17.33	133.23
0.37	0.21	17.30	14.05	2.75	5.18	39.86
0.92	0.53	43.40	35.24	6.91	13.01	
Not suitable						
1.21	1.14	17.03	12.13	3.90	7.16	42.56
0.36	0.34	5.09	3.63	1.17	2.14	12.73
2.84	2.67	40.01	28.50	9.16	16.81	
Total						
4.18	1.94	181.16	77.07	16.93	52.97	334.24
1.25	0.58	54.20	23.06	5.06	15.85	

** Classes are the following 1) Urban area less than 500 person/km^2 and 1 km. from the road, 2) Urban area less than 500 person/km^2 and 2 km. from the road, 3) Rural area less than 500 person/km^2 and 1 km. from the road, 4) Rural area less than 500 person/km^2 and 2 km. from the road, 5) Urban area greater than 500 person/km^2 and 1 km. from the road and 6) Urban area greater than 500 person/km^2 and 2 km. from the road

Table 8. Land Area of Potential Areas for Settlements Expansion by Distance from the Shore

	1 km.	3 km.	4 km.	5 km.	Total
Most suitable					
Area (km^2)	0.00	0.00	1.05	3.93	4.97
Total %	0.00	0.00	0.35	1.31	1.66
Row %	0.00	0.00	21.02	78.98	
Suitable					
Area (km^2)	0.00	1.54	25.26	34.49	61.29
Total %	0.00	0.51	8.42	11.50	20.44
Row %	0.00	2.51	41.21	56.28	
Fairly suitable					
Area (km^2)	0.00	13.33	42.16	48.65	104.14
Total %	0.00	4.44	14.06	16.23	34.73
Row %	0.00	12.80	40.48	46.72	
Not suitable					
Area (km^2)	13.88	16.76	46.09	52.72	129.44
Total %	4.63	5.59	15.37	17.58	43.17
Row %	10.72	12.95	35.60	40.73	
Total	13.88	31.62	114.55	139.79	299.84
	4.63	10.55	38.20	46.62	

Conclusion and Recommendations:

Determining lands suitable for settlements entail the analysis of natural and physical features of the area as well as the proximity of these areas to existing population centers or high density areas, although not necessarily classified urban, and proximity to roads. Encouraging growth of settlements along roads in existing urban areas with densities less than 500 or in rural areas with densities higher than 500 may perpetrate the ribbon pattern of development. In these areas, land conversion and preservation policies need to be adopted.

The study results need further refinement to consider development constraints, particularly the vulnerability of the areas to such natural hazards as earthquakes and floods. Such analysis will lead to the identification of appropriate land use control measures designed to reduce, if not eliminate damage from exposure to hazards and risks.

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Identification and Assessment of Coastal Tourism Areas in Lingayen Gulf

Agnes G.A. Cargamento[1], Edwin Cacanindin[1], Konifacio. Q. Casuga[1]

Abstract

Coastal tourism has continued to be an important economic activity in Region I, especially in the Lingayen Gulf area. As the region's development in the next five years is hinged in part on tourism, planning efforts have been intensified and are focused on the identification of attractions or areas with tourist potentials.

This study assesses the existing tourist resorts and establishments within the gulf area and identifies potential expansion and development areas with the use of geographic information systems (GIS). Criteria for assessment and site identification are based on existing guidelines and regulations for tourism inventory and analysis used by the Department of Tourism (DOT), current/existing land use and physiographic characteristics of the gulf area. The attempt to include environmental/ecological factors/considerations in the assessment was constrained by the dearth of data.

Introduction

The Lingayen Gulf area with its fine extensive sandy beaches, natural scenic areas such as the Hundred Islands, coupled with its rich history and culture, has offered aesthetic attractions that continue to draw tourists into the region. The major tourist spots in the area are the coastal stretch from Bauang to Agoo in La Union and the Hundred Islands in Pangasinan, which areas form part of the tourist zones declared as tourism investment priority areas under Letter of Instruction No. 75 issued on 22 May 1973. These areas can be transformed into significant tourism zones that will optimize the use of their natural assets and attractions as well as existing facilities.

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It is said that tourism development, and for that matter recreation development, shares a common ground with the management and the quality of the environment. The Action Plan for Recreation and Tourism of the Lingayen Gulf Coastal Area Management Plan (LG-CAMP) cited several observations demonstrating this relationship, strongly indicating that the survival of tourism in the Lingayen Gulf largely depends on the environmental quality and integrity of its coastal and marine resources.

The management and protection of the Lingayen Gulf's natural features with high tourism potential is important for scientific, cultural, historic and ecological purposes as well as for economic reasons in terms of their income-generating potentials.

This study assesses existing and potential tourism sites and the results shall be used as guide in fleshing out the region's tourism development plans, particularly in terms of delineating appropriate if not optimal locations of tourism development, and as inputs for assessing/evaluating proposed tourism programs and projects in the area.

Methodology

This study used the geographic information systems (GIS) technology to assess existing tourism areas in terms of facilities and identify potential tourism zones for land- and water-based recreation. The establishment of the data base for the study involved the following general steps (See Annex 1 for the detailed methodology).

Existing tourism areas identified by the Department of Tourism (DOT) (See Table 6.2) were digitized using the GIS software called SPANS. These areas are classified as historical, cultural, religious, man-made and natural scenic attractions. Likewise the existing tourist resorts and facilities accredited by the DOT (See Table 6.1) were digitized.

In addition, the physical resource characteristics of Pangasinan and La Union (as contained in the 1990 landuse maps, soil maps and physiographic maps sourced from the Bureau of Soils and Water Management (BSWM) with scales ranging from 1:50,000 to 1:100,000) were likewise digitized. The 1990 urban-rural classification of barangays taken from the 1990 census (NSO 1990) was tagged to the barangay map digitized from the DENR's 1:10,000 cadastral maps. Latest digital road data were imported into SPANS from the digital base data from the Department of Public Works and Highways (DPWH) generated from the data files of the Northwestern Luzon Growth Quadrangle (NWLGQ) Project.

Figure 1

Identification and assessment of Coastal Tourism Areas in Lingayen Gulf

Flow of Processing Tasks (SPANS Language)

A: Identifying existing resort areas

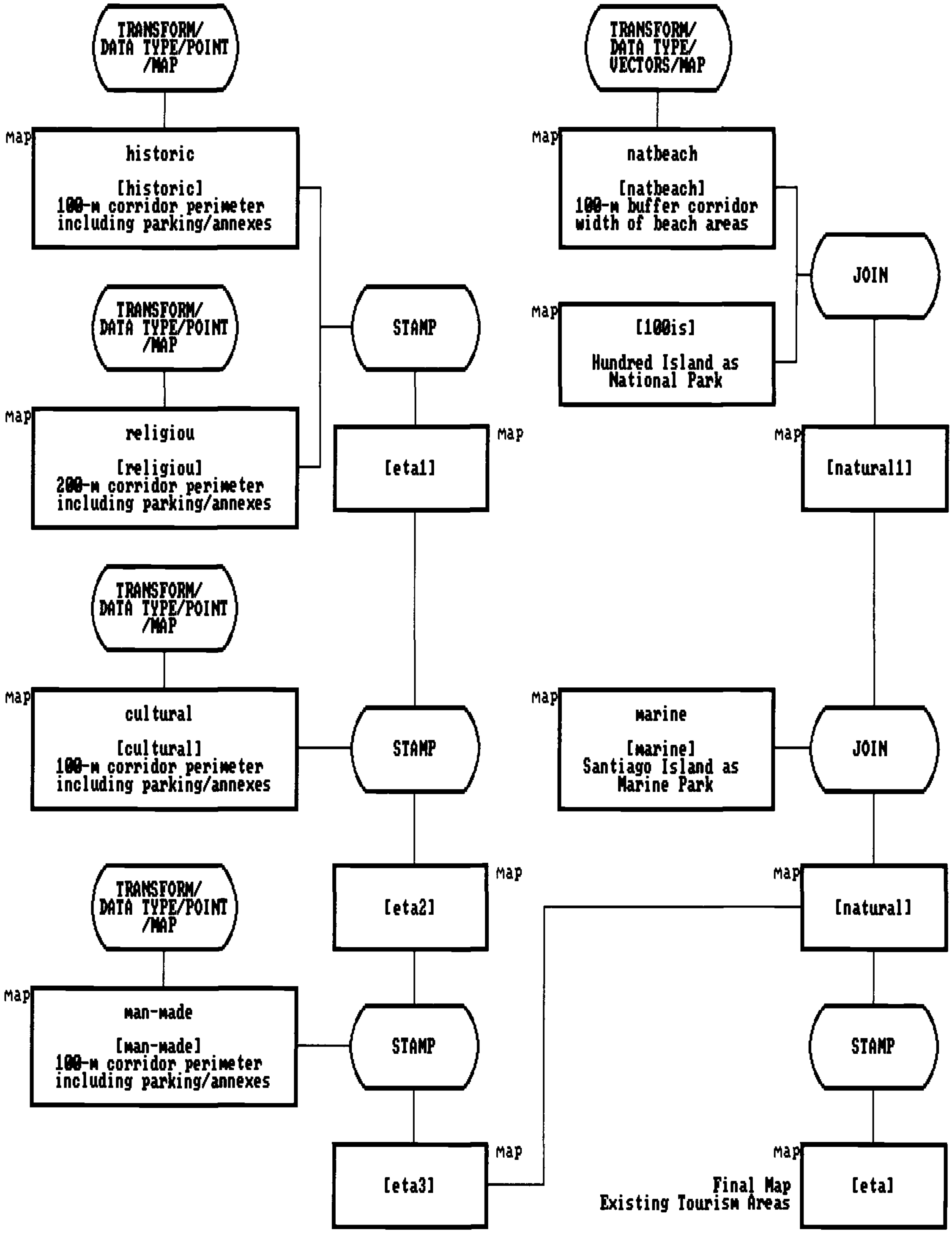


Figure 2

Identification and assessment of Coastal Tourism Areas in Lingayen Gulf

Flow of Processing Tasks

B: Generation of beach showing suitable areas for coastal resort

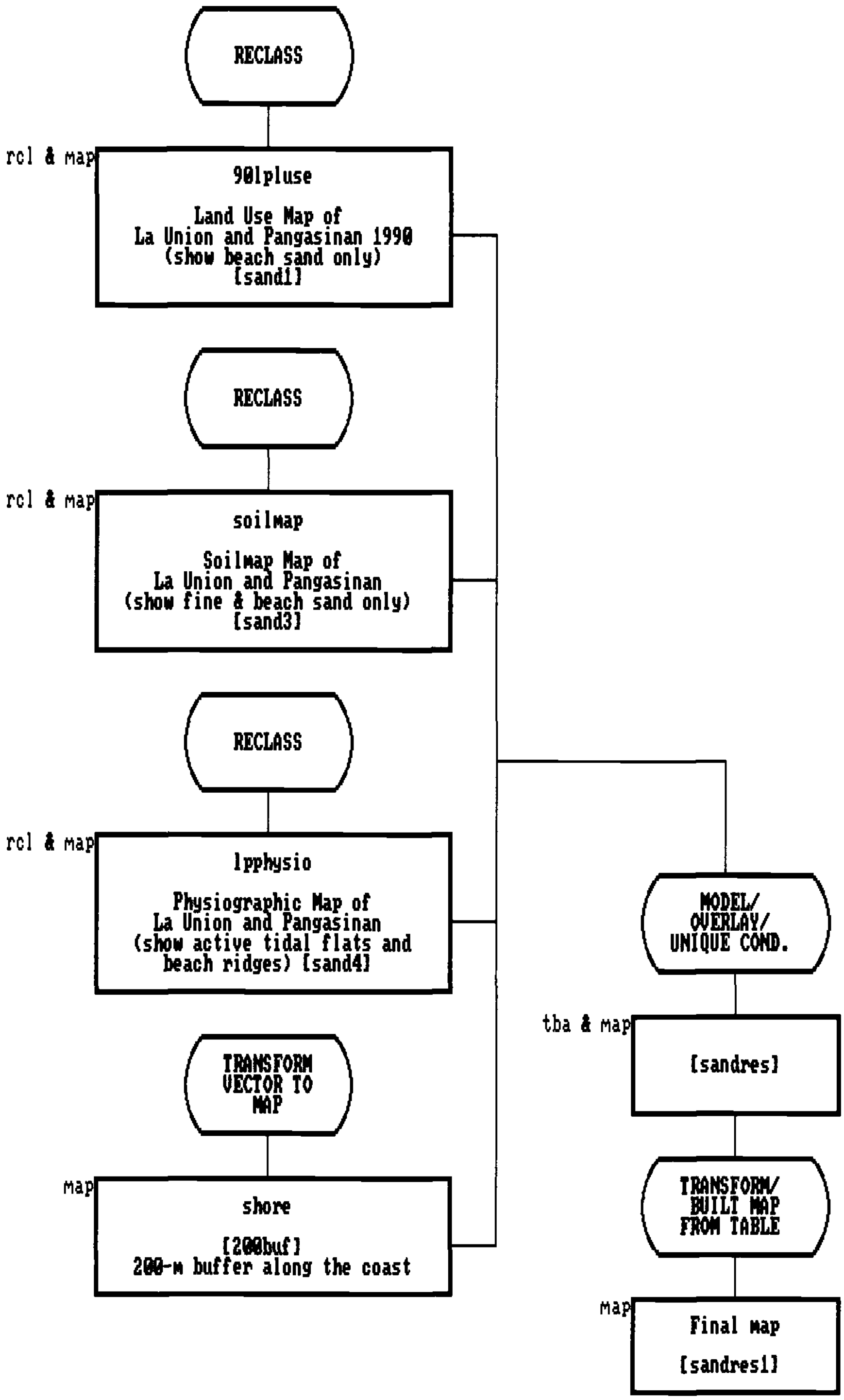


Figure 3

Identification and assessment of Coastal Tourism Areas in Lingayen Gulf

Flow of Processing Tasks

C: Identification of potential tourism areas

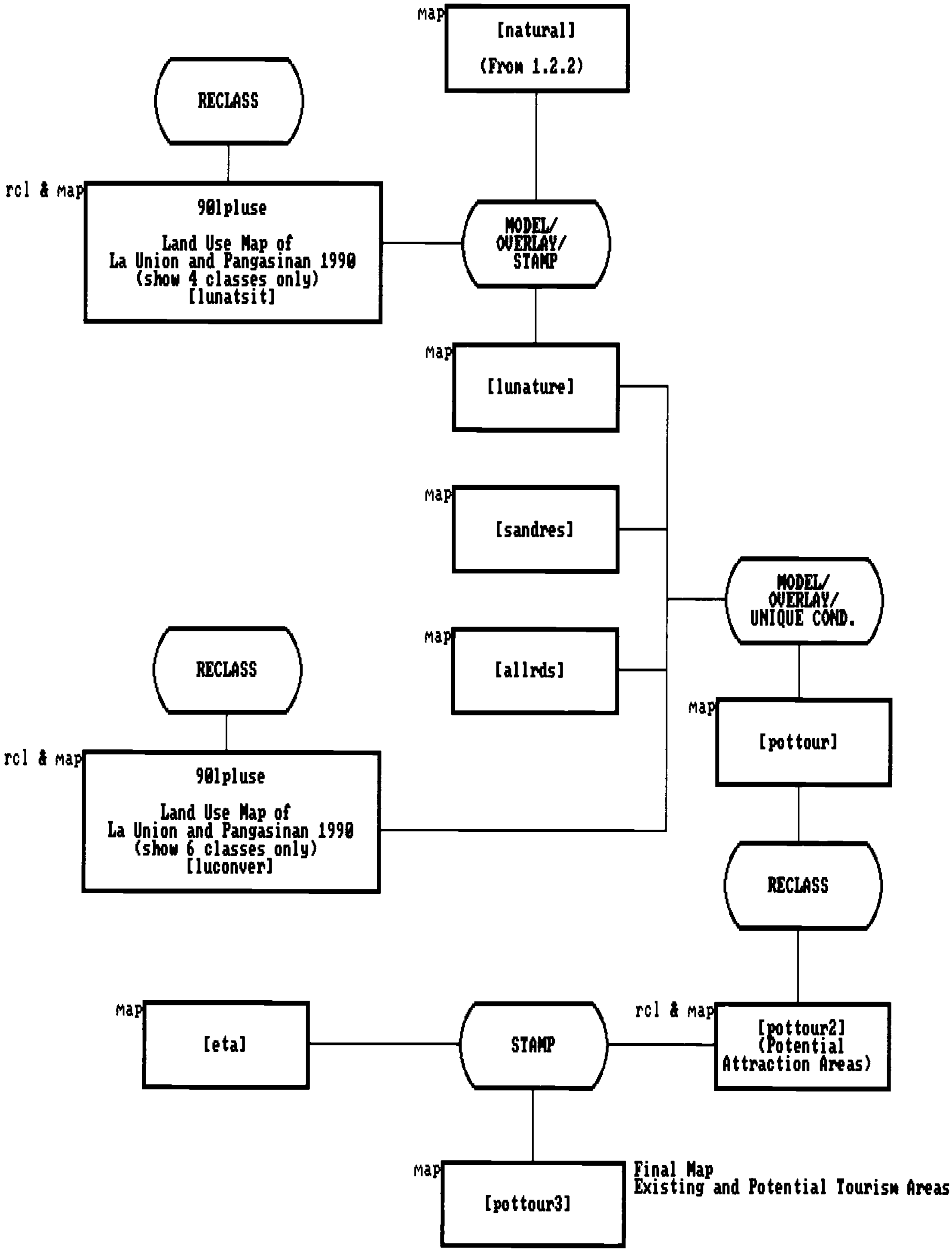


Table 6.2
TOURIST ATTRACTIONS

Classification	Tourist Attraction	Description/Location	Province	Municipality	Barangay
Historical	Bacsil Ridge	Located 9 kms. northeast of San Fernando town proper through San Fernando–Bagulin road. It was the last bastion of the retreating Japanese Imperial Army in the province. Later it constituted the East Flank of the 21st Infantry of the United States Armed Forces in the Philippines–Northern Luzon during the Liberation	La Union	San Fernando	Bacsil
	Wallace Air Station	This 101 hectares of land located at the end of Poro Point was acquired in 1903 for the United States Cavalry. It was the home of the 848th Aircraft Control and Warning Squadron which provided logistics and administrative support to other radar detachments under its chain of command. Formally turned over by the US government to the Republic of the Philippines on September 16, 1991.	La Union	San Fernando	Poro
	Battle of San Fernando Marker	Situated at the northwestern portion of the Town Plaza. Inscribed in the marker is how the battle was started and won enabling the establishment of the US Army at Poro Point eventually used as build up area for the projected invasion of Japan.	La Union	San Fernando	Town Plaza
	Tomb of the Unknown Soldiers	Located at the junction leading to Poro Point, San Fernando. Built as a tribute to the soldiers who fought during the last war.	La Union	San Fernando	Sevilla

Classification	Tourist Attraction	Description/Location	Province	Municipality	Barangay
	San Nicolas Beach	This strech of beach fronting Agoo Playa Hotel and which is a part of the Agoo–Damortis National Park was where the Japanese traded with the natives during the pre–SPanish time earning for Agoo the name "Puerto de Japon".	La Union	Agoo	San Nicolas
	Darigayos–Paraoir Beach	Site of the Camp Spencer, the general headquarters of the USAFIP–NL during the liberation of northern Luzon. Darigayos was the landing site of the US Navy Submarine "GAR" which unloaded arms, communication equipment and ammunition for the Liberation forces.	La Union	Bacnotan & Balaoan	
	Lingayen Public Beach	This portion of the Lingayen Gulf fronting the Provincial Capitol is the setting of the annual "Pistay Dayat." A favorite of beachcombers, facilities like picnic sheds and bathhouses were put up by the Philippine Tourism Authority and private individuals. The beach was one of the landing areas of the American Forces during the Liberation of Northern Luzon.	Pangasinan	Lingayen	
	White Beach	The beach stretching from Nibaliw West to Bolasi in San Fabian was the landing area of Lt. General Homma, commander of the Japanese Imperial Expiditionary Forces on 24 December 1941. In 1945, the beach became one of the areas of operation of the Liberation Forces in Northern Luzon.	Pangasinan	San Fabian	

Classification	Tourist Attraction	Description/Location	Province	Municipality	Barangay
	Limahong Channel	The Chinese Corsair Limahong, having been foiled of his attempt to find a colony on the shore of Manila Bay proceeded north to Pangasinan, the bailwick of Princess Urduja where he dug a channel in Domalandan, Lingayen that served as his escape route towards the China Sea.	Pangasinan	Lingayen	
	Mac Arthur Landing Marker	A statue of Gen. Douglas Mac Arthur stands in the vicinity of Bonoan Blue Beach, Dagupan where he landed during the Liberation.	Pangasinan	Dagupan City	
	Home Economics Building, West Central Elementary School	Located on Burgos Street in Dagupan, the building became the temporary headquarters of Gen. Mac Arthur after landing in Bonoan.	Pangasinan	Dagupan City	
	Old St. John's Cathedral	It was in the old cathedral on Zamora Street where the Spanish General Coballos surrendered to the Filipino military strategist, General Francisco Makabulos during the Philippine Revolution.	Pangasinan	Dagupan City	
Cultural	Museo de La Union	Found West of the Provincial Capitol, the museum showcases the archeological find in La Union as well as dioramas of identified habitation/ contact areas during the pre–Spanish period.	La Union	San Fernando	
	Watchtowers	These structures found in the Ilocos coasts were used to warn the natives of the coming Moro pirates. Still standing are the watchtowers in Carlatan, San Fernando, Bacnotan, Balaoan and Luna.	La Union	San Fernando	

Classification	Tourist Attraction	Description/Location	Province	Municipality	Barangay
	Pottery	The clay products in the past were mostly used for cooking and storing. However, with the introduction of metal wares the makers shifted to the manufacture of decorative clay articles and other accessories. Pottery making is witnessed in Taboc, San Juan where finished products are on display along the highway.	La Union	San Juan	
	Blanketweaving	This age-old practice of weaving wider Ilocano blankets with the use of looms operated manually by two persons is still a prime home industry in Bangar. Likewise, placemats, towels, draperies and curtains are produced commercially.	La Union	Bangar	
	Basimaking	Basi, the Ilocano native wine concerted from sugar cane juice and bark of duhat tree for the coloring is produced in Lioac, Naguilian. Process of preparation from the extraction of the sugar cane juice with a wooden mill to the finished product is the same as in the past. Taste of the basi differs from one producer to another. Basi is also produced in Luna.	La Union	Naguilian	
	Cigarmaking	The town of Tubao is famous for its quality wrapper tobacco products which are exported to other countries.	La Union	Tubao	
	Bolinao Museum	The museum beckons studies-inclined visitor to its preserves of art, geology, botany and zoology materials collected in the area. It is located at Rizal Street just across the Cape Bolinao High School.	Pangasinan	Bolinao	

Classification	Tourist Attraction	Description/Location	Province	Municipality	Barangay
	Narciso Ramos Museum	Housed at the Asingan Municipal Hall are the memorabilia of the former Ambassador and father of President Fidel V. Ramos.	Pangasinan	Asingan	
Natural	Bauang Beach	The stretch of grayish sand beach in the northern barangays from Baccuit to Pagdalagan are lined with tourist establishments providing accommodation and amenities to visitors. The calm, crystal–clear water of the China Sea in this area is ideal for swimming, waterskiing and boating.	La Union	SF & Bauang	
	White Sand	Take a banca from Bauang beach to this secluded white sand beach in Poro Point for snorkeling. Far out into the sea are scuba diving.	La Union	San Fernando	
	San Francisco–Canaoay–Pagudpud Beach	Privately owned cottages and tourism related establishments line this nearly white sand beach area in San Fernando.	La Union	San Fernando	
	San Juan Beach	The seashore of San Juan starting in Urbiztondo up to Ili Norte is dotted with tourism related establishments. The surf is recommended for amateur board surfers during the months of November to February.	La Union	San Juan	
	Caba Beach	San Carlos and Santiago Norte beaches are becoming to be favorite sites for private beach houses and resorts. The sand is nearly black because of the metallic deposit of iron and is believed to be therapeutic.	La Union	Caba	

Classification	Tourist Attraction	Description/Location	Province	Municipality	Barangay
	Hundred Islands National Park	Scattered off the coast of Lucap in Alaminos are 123 islands and islets looking like giant turtles comprising the 1,844 hectares nature/recreational park. On many points between the islets, the waters are shallow enough for swimming, boating and snorkelling. The Quezon Island has picnic sheds, toilets and view decks. Children's Island is the campers' place while the Governor's Island has facilities for accomodation. Reservations are accepted at the Public Assistance Center at Lucap where motorized bancas for trips to the islands are also hired. Lucap is approximately 3 kms. from the Alaminos Municipal Hall thru the San Jose Drive.	Pangasinan	Alaminos	
	Santiago Island	The island is a haven for scuba divers with its rich preserves of corals teeming with marine life and shells. It is situated off the north–east coast of Bolinao and about 96.7 kms. from Dagupan from the port which is a stone's throw away from the Bolinao municipal building.	Pangasinan		
	Agno Umbrella Rocks	These mushroom shaped coral stone boulders dot the mouth of Balincaguing River in Sabangan, Agno. The nearby area has a potential for development as a public beach.	Pangasinan	Agno	
	Binmaley Public Beach	The beach has picnic sheds and other amenities.	Pangasinan	Binmaley	

Classification	Tourist Attraction	Description/Location	Province	Municipality	Barangay
	Cabongaoan Beach	A white beach in Burgos frequented by the locals during the dry season about 18 kms. from the townproper.	Pangasinan		
	Cape Bolinao Beach	A white beach in Barangay Patar ideal for tourism development. Nearby is a freshwater source believed to be the outlet of an underground river.	Pangasinan	Bolinao	
	Cacupangan Cave	Before reaching the townproper of Mabini from Alaminos, turn left at the Cemetery Road then proceed eastward to the cave which is approximately 5 kms. away through rough road. Its underground river flows into the Balincaguing River. Exploring the cave and its vicinity is a recommended activity during the dry season.	Pangasinan	Mabini	
	Tambobong White Beach	This stretch of white sand beach in the municipality of Dasol is accessible by land 10 kms. from the town proper of Burgos.	Pangasinan	Dasol	
	Bonoan Beach	A wide stretch of beaches along the Lingayen Gulf in Dagupan which includes the famous Tondalingan Ferdinand now called the Peoples' Park.	Pangasinan	Dagupan City	
	Maleluag Hot Springs	The DENR maintains the resort which is located about 7 kms. uphill climb along the highway in Mangatarem.	Pangasinan	Mangatarem	

Classification	Tourist Attraction	Description/Location	Province	Municipality	Barangay
Religious	Shrine of Our Lady of Namacpacan	The century-old church of St. Catherine in Luna formerly called Namacpacan houses the miraculous image of our Lady of Namacpacan, patroness of Ilocano travellers.	La Union	Luna	
	Shrine of Our Lady of Charity	Enshrined in the Basilica de Minore of Agoo is the image of the Lady of Charity. The image was found to be untouched despite the destruction of the church by an earthquake in 1892. The Mexican-baroque structure was badly damaged during the 1990 earthquake but has been repaired and renovated.	La Union	Agoo	
	Macho Temple	Located at a promentory at the northern part of San Fernando overlooking the San Fernando Bay. Macho Temple houses a replica of the Virgin of Caysasay. Construction of temple which has a unique architecture specifically its dome and five gates was spearheaded by the Filipino-Chinese communicty in San Fernando.	La Union	San Fernando	
	Shrine of the Nuestra Señora de Manaoag	Devotees flock to the shrine of the "Apo Baket" believed to be miraculous asking for her intercession. Dawn processions are held on the first Saturday of every month. The Feast of the Our Lady of the Most Holy Rosary, patroness of the sick, the helpless and the needy is celebrated after the Holy Week.	Pangasinan	Manaoag	

Classification	Tourist Attraction	Description/Location	Province	Municipality	Barangay
	Sanctuario del Señor Divino Tesoro	The shrine of Christ is beside the Calasiao municipal buikding drawing devotees from towns outside Pangasinan. A nine-day novena celebrating its feast starts on April 24 and culminates with a 3-day festivity on May 2 to 4. Legend says that the small icon grew to its present man-like size.	Pangasinan	Calasiao	
Man-Made	Freedom Park	On the side of the stairway leading to the RDC building at Guerrero road are status of Filipino heroes.	La Union	San Fernando	
	Grape/Guapple Farms	Grapes grown in temperate countries can be acclimitized in the tropics as exemplified by the grape farms along the highway in the southern and northern barangays of Bauang and Caba. Guapples also abound in the area.	La Union	Bauang & Caba	
	Marcos Bust	Travellers going up to Baguio via the Marcos Highway get a glimpse of the concrete structure upon reaching Palina, Pugo. A vantage point to have a glimpse of the rustic scenery.	La Union	Pugo	
	Sericulture	Stages in silk production from the growing of the worms to the finished product which is silk are explained and witnessed at the Don Mariano Marcos Memorial State University in Sapilang, Bacnotan.	La Union	Bacnotan	

Classification	Tourist Attraction	Description/Location	Province	Municipality	Barangay
Special Interest					
Diving Areas	Black Buoy	Marking the right side of the channel on departure located at the mouth of San Fernando Harbor. The reef is mostly flat on top and to the east, 30 to 40 feet deep. Beast area is about 100 yards north of the buoy along the drop–off in 40 to 70 feet of water. Caverns and coral heads with lobsters and nice grouper (up to 100 pounds), a nurse sharks and large turtles have been seen.	La Union	San Fernando	
	Research Reef	Less than a mile south of Tamyo Reef. Several tunnels, caverns and crevices make it an excellent dive. Beginners must beware of caverns as some are tight fit and go in quite far. (The reef is adjacent to the Bauang beach).	La Union	Bauang	
	Fagg Reef	Located at 330 degrees approximately two (2) miles from the tip of Poro Point. Large flat reef at forty (40) feet with sharp drop–offs to the north and west sides. Best area is to the north, drop in and drift with the current to the north where the coral heads are big enough for ten (10) divers to crawl under and still have places for fish to hide. Lobsters are large but hard to find under the coral heads, Moray eels are up to 150 pound and 8 feet long. Sharks, barracuda, sea snakes and lots of friendly sea creatures adorn the area. Visibility is nearly excellent always.	La Union	San Fernando	

Classification	Tourist Attraction	Description/Location	Province	Municipality	Barangay
	Our Lady of Lourdes Grotto	Developed by the Ostrea family on a hillside along the highway in Bungol, Balaoan where mass is offered every first Saturday of the minth at 5:00 in the afternoon.	La Union	Balaoan	
	Church of St. James	The Bolinao church was built by the Augustinians in 1609. It houses wooden santos nowadays a rarity. The antique size altar is flanked by the two grinning tongue–portruding aztec visages presumably of Mexican influence and brought over by the Galleon Trade.	Pangasinan	Bolinao	
	Cape Bolinao Lighthouse	The structure was built by the American in 1903 on a 300 feet promontory at the western part of Cape Bolinao. It is still used to guide ships taking refuge at the cove during stormy weather.	Pangasinan	Bolinao	
	Sual Fishing Port	The port in Sual Bay is the main fiching port in Region I with facilities such as fish markets, ice plant and cold storage, berthing, net drying, repair area and dry docking.	Pangasinan	Sual	
	Oceanographic Marine Laboratory	Located at Lucap and operated by the Department of Agriculture.	Pangasinan	Alaminos	

Classification	Tourist Attraction	Description/Location	Province	Municipality	Barangay
	Tamyo Reef	South of Poro Point is a small and deeper reef known locally as Tamyo. Water is 40 to 85 feet with nice crevices. Several large fish have been taken here. Good lobstering at night.	La Union	San Fernando	
	Fourteen Mile Reef	The reef is several kms. long and is actually an extension of the western edge of Lingayen Gulf off the coast of Santiago Island. It has some hard and soft coral growth many shells, a good variety of fish. The gradual slope ranges from 10 to 40 meters with the western edge dropping abruptly to over 250 meters. This drive is not for novices.	Pangasinan		
	Devil's Island	Considered as best place for scuba diving at the Hundred Islands National Park.	Pangasinan	Alaminos	
Surfing	Monaliza	Monaliza in Urbiztondo, San Juan is considered to be one of the premier spots in the Philippines. catches swells like a giant magnet, good power on winter N swells with jacking peaks, long walls and an inside bowl all rights. Between Monaliza's and Bacnotan is a long beach with some breaks lover sandbars best for beginners. Recommended time for surfing is between November and February.	La Union	San Juan	
Splunking	Bolinao Multi–chambered Cave	Located at barangay Tara and is approximately one kilometer away from the highway. Coming from Alaminos, Tara is 12 kms. before reaching the townproper.	Pangasinan	Bolinao	

Table 6.1

TOURIST RESORTS AND FACILITIES

Name/Address/Telephone Number of Establishment	Contact Person	Classification	Number/ Type/Rate of Rooms	Facilities
Agoo Playa Hotel San Nicolas, Agoo 234; 290	Mr. Ricardo Soler	Class "AAA" Resort	36 aircon rooms De Luxe Twins P 1,250.00 Single P 1,124.00 Standard Twins P 1,005.00 Single P 875.00	Swimming Pool Tennis Court Function Rooms Parking Area
Cresta del Mar Resort and Beach Club Paringao, Bauang 41–32–97; 41–31–97	Mr. Juan Sta. Ana, Jr.	Class "AA" Resort	17 Regular Suite P 1,064.00 10 Bachelor Suite P 1,232.00 4 De Luxe P 1,120.00 10 Family Suite P 2,520.00 Extra person P 250.00 (inclusive of taxes)	Restaurant, Conference rooms, Indoor Sports Equipment, Bar, Disco, Gift Shop, Swimming pool, parking space
Acapulco Beach Resort San Francisco, San Fernando 41–26–96; 41–26–97	Mr. Emiliano Veneracion	Class "AA" Resort	27 Twin Bedded room P 615.00 9 Doubles P 800.00	Restaurant, Multi–purpose hall, parking space
China Sea Beach Resort Paringao, Bauang 41–48–21	Mr. Rodolfo Ramos	Class "A" Resort	13 Fan rooms on season P 600.00 off season P 550.00 6 aircon rooms on season P 750.00 off season P 650.00	Restaurant, Swimming pool, Bar, Outdoor sports equipment, Scuba diving equipment
Caba"a Beach Resort Paringao, Bauang 41–28–24; Fax 41–44–96	Mrs. Carolina Rossiter	Class "A" Resort	26 Doubles P 750.00 3 Family rooms P 850.00 Extra bed P 100.00	Restaurant, Conference hall, Swimming pool, Indoor game equipment, Mini golf, Dive shop

Name/Address/Telephone Number of Establishment	Contact Person	Classification	Number/ Type/Rate of Rooms	Facilities
Lazy "A" Beach Resort Nibaliw West, San Fabian 47–26			2 Bunaglow with 4 beds, bath and kitchen facilities (20 pax) P 1,300.00 2 Bungalow with 2 beds bath and kitchen facilities. P 1,000.00 6 Single with bath P 450.00 4 Aircon with bath P 600.00	Pavilion; Restaurant; Swimming Pool; Sauna bath, Parking area
Center Beach Nibaliw West, San Fabian	Mr. Jason Mejia		4 Cottage P 70.00 to P 600.00 7 Rooms P 100.00 to P 600.00	Picnic sheds Pavilion Parking area
Maria Angela Inn Guiguinawen, Mangaldan	Mrs. Maria de Vera	Tourist Inn	7 Twin aircon with bath P 240.00 1 non–aircon with bath P 200.00	Function room (150 pax); Parking area Dining hall
Hotel Victoria A.B. Fernandez Avenue Dagupan City 20–81	Mr. Gonzalo Zarate		Superior Twin aircon P 435.00 De Luxe Twin P 395.00 Family P 500.00 De Luxe Single P 345.00 Honeymoon suite P 600.00 Standard twin non–aircon P 325.00 Extra bed P 95.00 (rates inclusive of taxes)	Restaurant Souvenir shop Parking area
Celeste Sea Breeze Germinal, Bolinao	Mr. Jesus Celeste		4 Single P 150.00 4 Triple P 200.00	Restaurant, Multi–purpos hall, Parking area, Motor bancas for hire
Boulevard Hotel Arellano Street, Dagupan 77–08		Lodging House	4 Double aircon P 300.00 Single non–aircon P 120.00 to P 150.00	Parking area Multi–purpose hall

Name/Address/Telephone Number of Establishment	Contact Person	Classification	Number/ Type/Rate of Rooms		Facilities
Maxime's By the Sea Lucap, Alaminos	Mrs. Maxima Rabot	Tourist Inn	5 Double non–aircon off season Holy Week 10 Double aircon off season Holy Week 5 Triple non–aircon off season Holy Week 2 Family room aircon (5 pax) off season/ Holy Week	 P 295.00 P 395.00 P 395.00 P 495.00 P 150.00 P 200.00 P 950.00	Restaurant, Multi–purpose hall (upper deck) Parking Area Boats for hire
Ciudad Fernandino Hotel and Restaurant Mac Arthur Highway Nancayasan, Urdaneta	Mr. Fernando Esguerra	Tourist Inn	8 Single aircon with bath 3 Double aircon 3 Single non– aircon	 P 400.00 P 450.00 P 300.00	Function room Restaurant, Curio shop, Parking area, Stand–by generator, Music lounge/disco (as requested)
Majoha Hotel and Restaurant Mac Arthur Highway Nancayasan, Urdaneta	Mrs. Marita Apolonio	Tourist Inn	14 Single aircon 3 Twin aircon 1 Triple aircon	P 480.00 P 600.00 P 1,000.00	Restaurant, Parking area, Stand–by generator, Function room (2)
Pangasinan Sea Breeze Resort Poblacion East, Sual	Mr. Teofilo de Vera	Tourist Inn	18 rooms Double aircon Family aircon	 P 350.00 P 450.00	Function room Parking area Motor banca for hire, Canteen
Prime Island Resort Tiblong, SAn Fabian 301–3664 (Cellular)	Ms. Prime Rose Yang		12 Cottage with 2 rooms and kitchen facili– ties 2 dormitory (15 pax) / head	 P 500.00 P 40.00	Meeting Room (200 capacity) Parking area

Name/Address/Telephone Number of Establishment	Contact Person	Classification	Number/ Type/Rate of Rooms	Facilities
Golden Heaven Pagdaraoan, San Fernando 41–35–17	Mrs. Linda Langit	Tourist Inn	3 Cottage aircon with 3 rooms P 2,500.00 1 Cottage with 3 rooms and fan P 1,500.00 2 Cottage w/room P 750.00	Pavilions canteen Parking area
Monaliza Cottages Urbiztondo, San Juan 41–48–92	Mrs. Norma Luebben	Lodging House	4 Good for 2 with common bath P 200.00 2 Good for 4 with bath P 220.00	Canteen
Salanga's Compound Pagudpud, San Fernando 41–38–02	Mr. Jorge Calica	Lodging House	2 Aircon w/ bath P 550.00 11 non–aircon with bath P 350.00	Picnic sheds, Parking area, Restaurant, Pavilion (150 pax)
Oceana Apartment Carlatan, San Fernando 41–51–35	Mr. Charlie Gapuz Te	Apartment–Hotel	31 Furnished apartments	Parking area
Southern Palms Beach Resort Pagdalagan Sur, Bauang	Mr. Jeffrey Jon Duncan		Aircon rooms 1 Family cottage P 975.00 1 Twin P 850.00 5 Beachfront suites P 675.00 2 Executive P 575.00 5 Standard P 475.00 Extra bed P 150.00	Restaurant, Bar Laundry service, Gift shop, Parking area
Sunset Bay Canaoay, San Fernando	Mrs. Emily Stalder	Lodging House	5 Double aircon with bath P 550.00 (inclusive of tax)	Restaurant Parking area
Bayview Hotel Gapuz Zigzag Rd, San Fernando	Mrs. Pacita Gualberto	Lodging House	4 Double aircon with bath P 200.00 5 Single aircon with bath P 200.00 4 Ordinary non–aircon with bath P 150.00	Restaurant, Disco Parking area

Name/Address/Telephone Number of Establishment	Contact Person	Classification	Number/ Type/Rate of Rooms	Facilities
Hotel Casa Blanca Rizal Avenue, San Fernando 41–31–32	Mr. Antonio Tan	Lodging House	4 Single with common bath P 70.00 2 Double aircon with bath P 250.00 11 Double non–aircon with bath P 120.00 14 Double with common bath P 90.00	Restaurant Parking area
Family Beach Baccuit, Bauang 41–22–30	Mrs. Pacita Gualberto	Lodging House	18 Fan rooms P 300.00 3 Aircon rooms P 500.00 3 cottages with 2 rooms P 600.00 Extra bed P 75.00 Extra person P 20.00	Restaurant Parking area
Hideaway Beach Resort Baccuit, Bauang	Mrs. Meselle Close	Lodging House	9 Double with fan off season P 250.00 on season P 450.00 4 Quadruple with fan off season P 250.00 on season P 450.00 Extra person P 50.00 (rates exclusive of taxes)	Restaurant, Bar Parking area
Jasmin Lodge Sevilla, San Fernando 41–24–59	Mrs. Alice Espinosa	Lodging House	4 Double aircon with bath P 300.00 6 Fan rooms P 150.00 4 Ordinary rooms P 85.00	Restaurant Parking area
D' Guesthouse at the End of the Road Poro, San Fernando 41–21–33; 41–34–11	Mrs. Cynthia Rivera	Lodging House	Phase I 28 Fan rooms P 180.00 Phase II 5 Aircon rooms P 300.00 Phase III 3 Aircon rooms P 400.00 7 Ordinary w/ fan P 250.00	Dining room Parking area

Name/Address/Telephone Number of Establishment	Contact Person	Classification	Number/ Type/Rate of Rooms	Facilities
Dagupan Village Hotel and Sports Center Lucao, Dagupan 26–74; 20–75	Mr. William Crossly		10 Twin with bath and color Television aircon P 650.00 15 Double aircon with bath P 650.00	Swimming Pool for check–in guests, Parking area, Restaurant Conference room 24 hour hot and cold water
Hotel Mil Exel 606 A. B. Fernandez East Dagupan 44–63	Mr. Maxima Bernal	Tourist Inn	11 Double aircon P 340.00 8 Non–aircon P 260.00	Restaurant Parking Area
Balingasay Perpetual Beach Resort Balingasay, Bolinao	Mr. Benjie Cabrera	Tourist Inn	6 Double aircon with bath P 375.00 2 Family (10 to 15 pax) P 1,000.00	Multi–purpose hall. Parking area, Dining hall
Hotel Cadena de Amor Mac Arthur Highway Calasiao 41–51; 38–78	Mrs. Angelita Labiano	Lodging House	12 Double aircon with bath P 300.00	Restaurant Multi–purpose hall, Souvenir shop, Parking area
The Last Resort Lucap, Alaminos	Mrs. Norma Buendia	Tourist Inn	9 Single/Double aircon with bath P 450.00 6 Single/Double non–aircon P 200.00 9 Twin aircon P 350.00 3 Twin non–aircon P 250.00 3 Family room aircon (8 pax) P 1,000.00 4 Family room non–aircon P 600.00 to P 800.00 9 Triple aircon P 550.00 4 Triple non–aircon P 350.00	Restaurant (70 seating capacity), Curio–souvenir shop, Multi–purpose hall, Motor banca for hire; Parking area

Name/Address/Telephone Number of Establishment	Contact Person	Classification	Number/ Type/Rate of Rooms	Facilities
San Fabian Presidential Resthouse Mabilao, San Fabian 20–52	Mrs. Lydia de Vera	Class "A" Resort	1 Master's room aircon P 1,952.00 1 Girl's room P 671.00 1 Boy's room P 671.00 4 Guest's room P 488.00 Extra Bed P 155.00 (rates inclusive of taxes)	Restaurant Pavilion Outdoor/Indoor Picnic sheds
Bagong Lipunan Lodge Mabilao, San Fabian	Mr. Ermin Garcia, Jr.	Tourist Inn	5 aircon with bath 10 rooms with common bath Rate: Hotel Accomodation with breakfast Family room Single occupancy P 1,200.00 Double P 560.00 Triple P 410.00 Quadruple P 335.00 Others with Private bath Single P 650.00 Double P 350.00 Triple P 275.00 with common bath Single P 520.00 Double P 300.00 Triple P 250.00 Quadruple P 210.00 Extra Bed P 100.00	Swimming Pool, Sheds, Pavilion, Conference room Parking Area, Indoor sports equipment, Restaurant
Sierra Vista Beach Resort Nibaliw West, San Fabian 76–68	Mrs. Teresita Dulnuan	Class "A" Resort	16 Double aircon P 930.00 Extra Bed P 200.00 3 Non–aircon P 750.00 Extra Bed P 100.00	Swimming Pool Restaurant/Bar Outdoor/Indoor Sports equipment Picnic sheds Parking Area

Name/Address/Telephone Number of Establishment	Contact Person	Classification	Number/ Type/Rate of Rooms		Facilities
			3 Triple	P 476.00	
			Non–aircon rooms		
			Phase I		
			3 Twin	P 308.00	
			1 Triple	P 364.00	
			1 Quadruple	P 392.00	
			1 Double	P 308.00	
			Phase II		
			2 Twin	P 330.00	
Miramonte Beach Resort Poro, San Fernando 41–44–08	Mrs. Gloria Dulay	Lodging House	8 Double aircon 2 Fan room 1 cottage with 2 rooms	P 450.00 P 300.00 P 900.00	Bar, Dining room
The Mirage Beach Club (formerly Blue Lagoon) Canaoay, San Fernando 41–25–31	Mr. Martin Koellner	Lodging House	6 Double aircon 2 Twin 3 Family	$ 22.00 $ 27.00 $ 35.00	Scuba diving equipment, water sports equipment, Bar Restaurant, Parking Area
Sunset Beach Resort Montemar Subd., San Juan 41–47–19	Mrs. Loenora Gaerthe	Lodging House	2 Double with fan	P 350.00	Restaurant
Mandarin House & Restaurant Quezon Avenue, San Fernando 41–28–28	Mr. Robert Lim	Lodging House	14 Double aircon with bath 3 without toilet and bath 5 Ordinary with common bath 2 Ordinary with bath	P 280.00 P 150.00 P 80.00 P 90.00	Restaurant

Name/Address/Telephone Number of Establishment	Contact Person	Classification	Number/ Type/Rate of Rooms	Facilities
Y Foods & Inn	Dr. Francisco Peralta	Tourist Inn	3 Single aircon P 230.00 8 Double aircon P 275.00 1 Double non–aircon P 165.00 3 Triple non–aircon P 240.00 3 Twin aircon P 275.00 2 Twin non–aircon P 165.00	Restaurant, Parking space
Carrille Terrace Carlatan, San Fernando 41–25–21	Mrs. Esperanza Rillera	Tourist Inn	4 Cottage (8 pax) P 750.00 14 Double P 300.00 1 Family P 500.00 16 Fan room P 250.00	Conference rooms Parking space
South Pacific Beach Apartel Paringao, Bauang 41–36–99	Mrs. Loida Sotelo	Tourist Inn	10 Cottage with common bath Weekdays & Sun. P 275.00 Saturday P 400.00 10 Twin with bath Weekdays & Sun. P 400.00 Saturday P 425.00	Restaurant Parking space
Ocean Deep San Francisco, San Fernando 41–44–40	Mr. Tim Aukshun	Special Interest Resort	2 Twin with bath P 300.00 6 De Luxe P 300.00 2 Economy P 200.00	Scuba diving equipment Parking space
Las Villas Beach Ili Norte, San Juan 41–52–79	Ms. Susanne Muezing	Pension House	2 Apartment type aircon P 750.00 3 Room type P 550.00 Extra person P 200.00	Restaurant, Bar Swimming pool Parking area
Plaza Hotel Quezon Avenue, San Fernando 41–22–96	Mrs. Emma M. Kaiser	"Economy" Class Hotel	Aircon rooms 21 Twin rooms P 442.00 1 Suite with ref. P 616.00 1 Suite P 588.00 2 Double P 442.00 1 De luxe P 588.00	Domestic/overseas telephone booths

Name/Address/Telephone Number of Establishment	Contact Person	Classification	Number/ Type/Rate of Rooms	Facilities
Fisherman's Wharf Resort Club Pagdalagan Sur, Bauang 41-42-53	Mrs. Myrna Coles	Class "A" Resort	8 Double aircon off season P 375.00 on season P 695.00 7 Double with fan off season P 325.00 on season P 650.00 Extra person P 120.00	Restaurant, Bar, Parking space
El Caseron Beach Resort Santiago Norte, Caba	Mr. Arnulfo Mirasol	Class "A" Resort	9 Double aircon off season P 700.00 on season P 800.00 2 Cottage with 2 rooms off/on season P 1,200.00 2 Single non-aircon off season P 500.00 on season P 600.00 Extra person P 200.00	Resataurant, Conference room (25 seating capacity), Parking space
Sun and Sand Beach Resort San Carlos, Caba	Mr. Manuel Manahan, Jr.	Class "A" Resort	6 Triple aircon with bath off season P 600.00 on season P 700.00 7 Cabaña non-aircon with 4 beds & bath off season P 500.00 on season P 500.00 2 Cottage with 2 rooms non-aircon off season P 1,200.00 on season P 1,600.00	
Villa Estrella Paringao, Bauang 41-27-11	Mr. Ambrosio Valero III	"Economy" Class Hotel	20 Twin aircon with bath P 750.00	Restaurant, Disco, Parking space

Name/Address/Telephone Number of Establishment	Contact Person	Classification	Number/ Type/Rate of Rooms		Facilities
Long Beach Resort–Hotel	Atty. Reynaldo Dulay	Class "A"	40 aircon rooms		Conference room,
Paringao, Bauang		Resort	Doubles w/o hot water		Restaurant, Bar,
41–26–73; 41–26–74			regular days	P 590.00	Souvenir shop, Indoor
			off season	P 375.00	sports equipment,
			holiday	P 725.00	Secretarial services
			Doubles w/ hot water		
			regular days	P 625.00	
			off season	P 438.00	
			holiday	P 855.00	
			Junior suite w/ hot water carpeted		
			regular days	P 750.00	
			off season	P 476.00	
			holiday	P 925.00	
			10 Family Cottages w/o hot water		
			regular days	P 1,250.00	
			off season	P 791.00	
			holiday	P 1,425.00	
			Fan rooms	P 500.00	
			Non–aircon	P 435.00	
Bali Hai Beach Resort	Mrs. Laureta de la Cruz	Class "A"	28 Double Aircon		Restaurant, Bar, Gift
Paringao, Bauang		Resort	with bath	P 750.00	shop, Parking space
41–25–04			2 Family cottage	P 1,100.00	
			2 Fan rooms	P 750.00	
			1 Family Cottage	P 975.00	
Coconut Grove Resort	Mr. Harry Anderson	Class "A"	12 Double aircon with bath		Swimming pool, Bar,
Bowls Club		Resort	off season	P 550.00	Restaurant, Outdoor
Paringao, Bauang			on season	P 750.00	sports equipment, Lawn
41–42–76			8 Family Cottage		bowling
			off season	P 700.00	
			on season	P 896.00	

Name/Address/Telephone Number of Establishment	Contact Person	Classification	Number/ Type/Rate of Rooms	Facilities
Nipa Hotel and Restaurant A.B. Fernandez Avenue Dagupan City 24–22	Mr. Nardo Donato	Lodging House	25 Single non–aircon P 55.00	Parking area Restaurant
Caliman Lodge I M. H. del Pilar Street Dagupan City	Mr. Bruno Calcaligong	Lodging House	3 Single non–aircon P 60.00 14 Double non–aircon P 70.00	Canteen
Holiday Village and Beach Resort Nibaliw, San Fabian	Mrs. Caridad Romero		12 Cottage (15 pax) P 500.00	Shower rooms Restaurant
Windsurf Beach Resort Alacan, San Fabian 912–305–5101	Mr. Frederic Borgeaud		16 non–aircon P 350.00 Entrance Fee per person except children P 10.00	Restaurant Public washrooms Picnic sheds Parking area Emergency generator
Ocean View Lodge Lucap, Alaminos	Mrs. Imelda Romero	Tourist Inn	8 Double non–aircon P 150.00 2 Family aircon P 550.00 5 Family non–aircon P 300.00	Restaurant Parking area
Guiamoy Lodge Lucap, Alaminos	Mr. Rodolfo Guiamoy	Pension House	4 Single non–aircon P 120.00 4 Double non–aircon P 160.00	Restaurant Lounge room Parking area
A & E Restaurant & Inn Germinal. Bolinao	Mr. Quintin Caasi		4 Single non–aircon P 60.00 5 Double non–aircon P 100.00 1 Family aircon P 350.00	Canteen; Parking area

Name/Address/Telephone Number of Establishment	Contact Person	Classification	Number/ Type/Rate of Rooms	Facilities
Nel–ars Travellers Inn Arellano Street, Dagupan 28–43	Dr. Ruby de Guzman	Tourist Inn	9 aircon with toilet & bath Single P 220.00 Double P 270.00 12 non;aircon Single P 150.00 Double P 170.00	Canteen
D'Rose Inn Laliag Street, Urdaneta 376	Mrs. Andrea Haduca	Lodging House	10 Double with bath; non–aircon P 120.00 2 Double with out bath P 70.00	Fastfood
Urdaneta Inn Mac Arthur Highway Nancayasan, Urdaneta	Mrs. Alice Fernandez	Lodging House	2 aircon Family with bath P 360.00 6 Double	
Pangasinan Village Inn Bued, Calasiao 25–25	Mrs. Loudes Fernandez	Economy" Class Hotel	19 aircon Twin with bath P 425.00 1 Family aircon with bath P 650.00	Function rooms Parking space Restaurant Swimming pool (for guest only)
Vicar Hotel A.B Fernandez Avenue Dagupan 26–16	Mr. Ramon Favila	Lodging House	6 Single non–aircon with bath P 120.00 16 Twin non–aircon with bath P 150.00 Add. person P 75.00	Restaurant Parking area Function room
Bayview Plaza Inn Bonoan, Dagupan 47–73	Mr. Antonio Duque		3 Single non–aircon without bath P 90.00 2 Single aircon without bath P 165.00 2 Single aircon with bath P 200.00 3 Double with bath aircon P 265.00 2 Double aircon without bath P 200.00	Canteen; Parking area

Name/Address/Telephone Number of Establishment	Contact Person	Classification	Number/ Type/Rate of Rooms		Facilities
			3 Twin non–aircon without bath	P 135.00	
Snow–White Drive Inn Boboan, Dagupan	Mrs. Mariqueta Capito	Motor–Hotel	12 Airconditioned units	P 392.00	
D'Sunrise Lodging House Urdaneta	Mr. Peter de Guzman	Lodging House	15 Non–aircon with common bath	P 120.00	
Bangsal Inn Nansangaan, Binmaley	Mrs. Marissa Diaz		4 Double aircon with bath	P 375.00	Restaurant Coffee–shop Function rooms Parking area Pavilions
			1 Double non–aircon with bath		
			4 Beach cottage Binmaley Beach	P 120.00	
Alaminos Travel Lodge Quezon Avenue, Alaminos	Mr. Roberto Bito	Lodging House	8 Ordinary Fan room without bath	P 80.00	Canteen
			4 Fan room Double with bath	P 130.00	
			4 Double aircon with bath	P 300.00	
Gelymar Traveller's Inn Perez Boulevard, Dagupan 45–15	Mrs. Corazon Esperacion		6 Single aircon with bath	P 300.00	Canteen; Parking area
			6 Double aircon with bath	P 350.00	
			6 Single Fan with bath	P 200.00	
			2 Double Fan room with bath	P 225.00	
Marjo Travellers Inn Bonoan, Dagupan	Mrs. Narciso Balolong	Lodging House	4 Double with bath	P 180.00	Canteen Parking area
			10 Dormitory type	P 70.00	
			2 Single ordinary with bath	P 80.00	

The existing resorts and facilities within the Gulf area accredited by the DOT were assessed considering room rates (with values ranging from P70.00 to P1,005.00 per room) and the type and number of rooms per registered/accredited resort.

For potential sites, the attractiveness and suitability for tourism of an area was determined largely from land use map evaluation/analysis within two categories: areas that can be converted to tourist sites (areal expansion) and areas that can be classified as tourist attractions without significant conversion. The former category involves areas that are either marginal or considered less economically productive while the latter category covers areas with scenic or natural attractions like forest and geological formations. Identification of potential sites was based on non-weighted map overlay. Other categories used in potential site identification are proximity to road and to urban areas/barangays as indication of the availability of support facilities, services and amenities required especially by foreign tourists.

In identifying potential tourism areas, the 1990 land use map was reclassified to generate a map showing only the following categories: grass, shrub, grapes, coconut , mango and bamboo - areas deemed for conversion as tourism areas because of either their natural features or their potential for development into additional and more productive use. Grasslands and shrublands were considered as potential tourism areas as these are marginal lands and can be easily converted to more productive use. Conversion priority, however, was based on the adjacency of a category to a tourism site(s).

This resulting potential tourism areas map was joined with the potential tourism development sites generated from the 1990 land use map reclassified this time to show only the following categories: mangrove, forest, beach sand and swamps; and the natural areas and marine park map (Santiago Island). The potential tourism development sites show areas for the preservation or conservation of natural resources and/or their natural recreational significance (e.g. beach sand).

Results and Discussion

The term tourism area for the purpose of this study would refer to destination attractions, or the elements within the destination's environment which, individually and/or combined, serve as the primary motivation for tourists to visit. These attractions include the natural attractions, historical sites, the cultural sites, religious sites and man-made attractions. (Developing a Regional Marketing Plan: Concepts and Considerations).

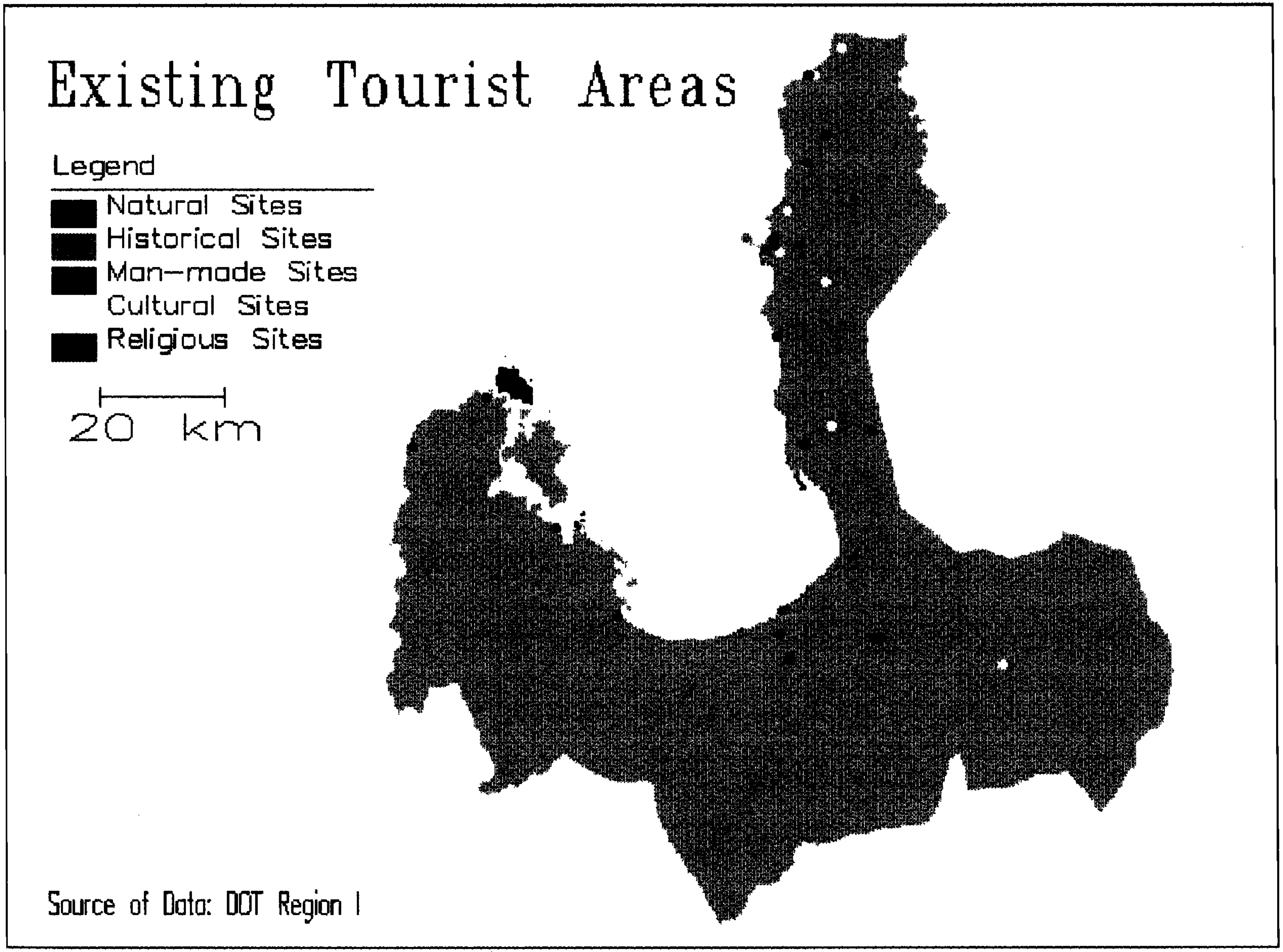
The mapping activity of the study indicates that there is no definite pattern in the location of existing tourism areas in the two provinces of Pangasinan and La Union. Although these are predominantly sea-based attractions, there is no geographical clustering of the tourist areas/attractions. However, there is a pattern in the location of tourism establishments: these are clustered along the beach near the urban centers of San Fernando and Agoo in La Union and Dagupan City. As these facilities are very close to the beach areas, they may be contributing to coastal pollution, particularly beach littering and water pollution coming from the discharge of insufficiently treated sewage/effluents. They may also have aggravated the damage and erosion of the sandy beaches by constructing seawalls and other supposedly protective structures right at the beachfront at the water's edge.

As the water quality data available is only for the Pangasinan area and because of the dearth of other data on coastal environmental quality, the study falls short of determining conclusively whether existing resorts do affect or not the quality of water near them or the identified tourism expansion or development sites are the best or the most attractive sites. It can be said, though, that many of the establishments in Pangasinan are near the areas where the water has been observed to be polluted.

From the assessment of existing tourism establishments, it is found out that of the 70 establishments assessed, 3 establishment are ranked very high standard (Rank 1 and 2), 22 are classified with high standard (Rank 3). This latter means that these establishments offer room rates relatively lower than the computed average room rate of all the resorts assessed at P537.00 inspite of their being classified highly by the DOT (See Table 6.3). These resort facilities/hotels offer a host of tourism and recreational opportunities including tennis courts, swimming pools and outdoor bowling as well as scuba diving, snorkelling, boating and sight-seeing. Overall, there are 25 establishments that have high standards while the rest are of average standard classification.

In terms of areal extent, there are about 39.38 km^2 of existing and potential tourism areas within the Lingayen Gulf coastal municipalities. Most of these areas (92%) are classified as natural sites, with more than 50% still remaining to be tapped/developed. These potential areas include the Santiago Island where a marine park is being proposed for establishment, the beach areas from Lingayen to San Fabian in Pangasinan and along the Sto. Tomas to Agoo and Bauang to San Juan coastal stretches in La Union.

There are other potential tourism attractions in the two provinces other than the water-based attractions. These include the forest areas in Eastern Pangasinan in the municipalities of Natividad and Umingan and in Northeastern La Union in the municipalities of Sudipen and Santol. There are also potential natural sites inland in Bugallon and Bayambang in Pangasinan.



Existing Tourist Areas
Legend
Natural Sites
Historical Sites
Man-made Sites
Cultural Sites
Religious Sites
20 km
Source of Data: DOT Region I

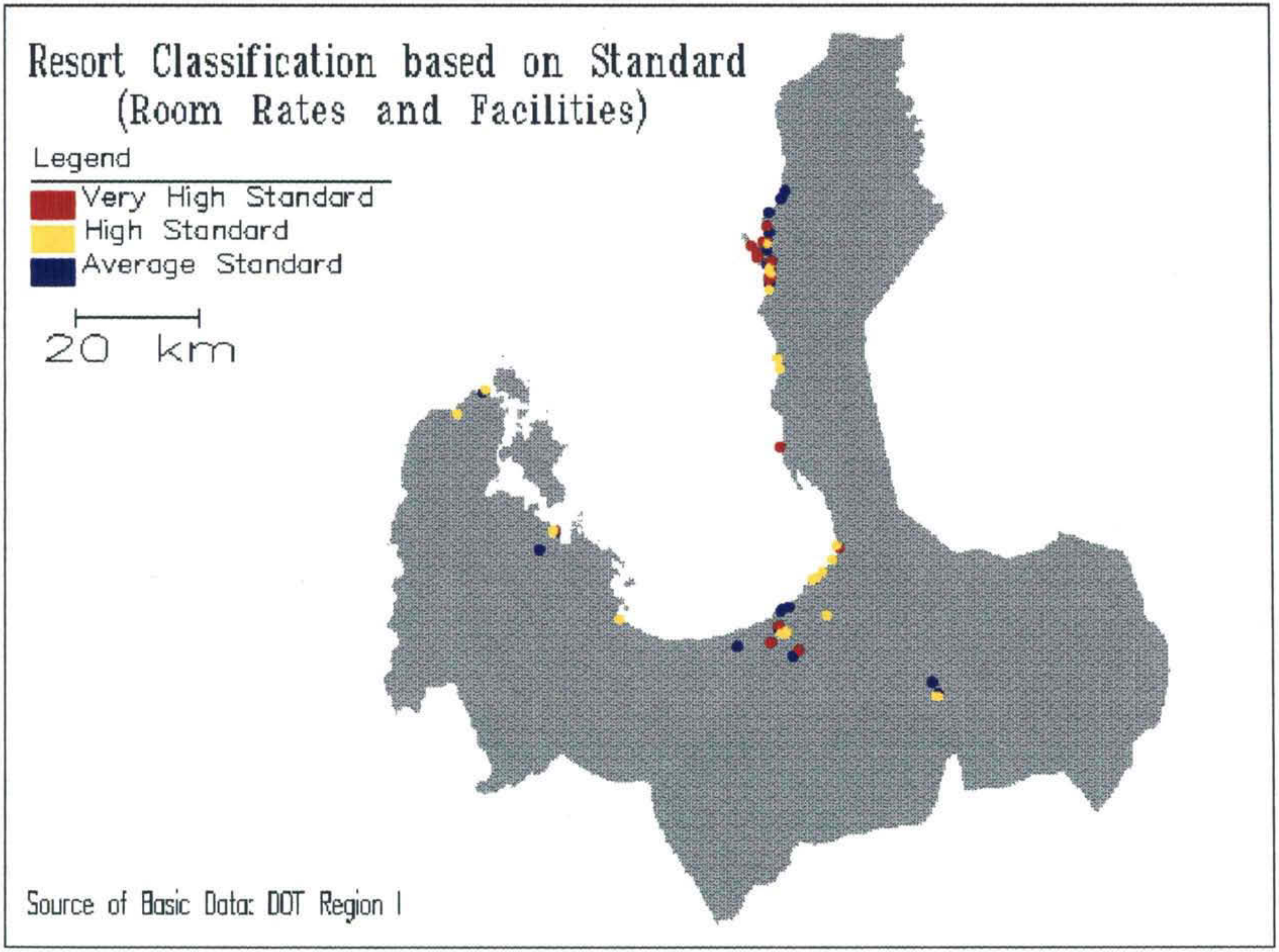
GIS CLASSIFICATION AND RANKING OF TOURIST FACILITIES

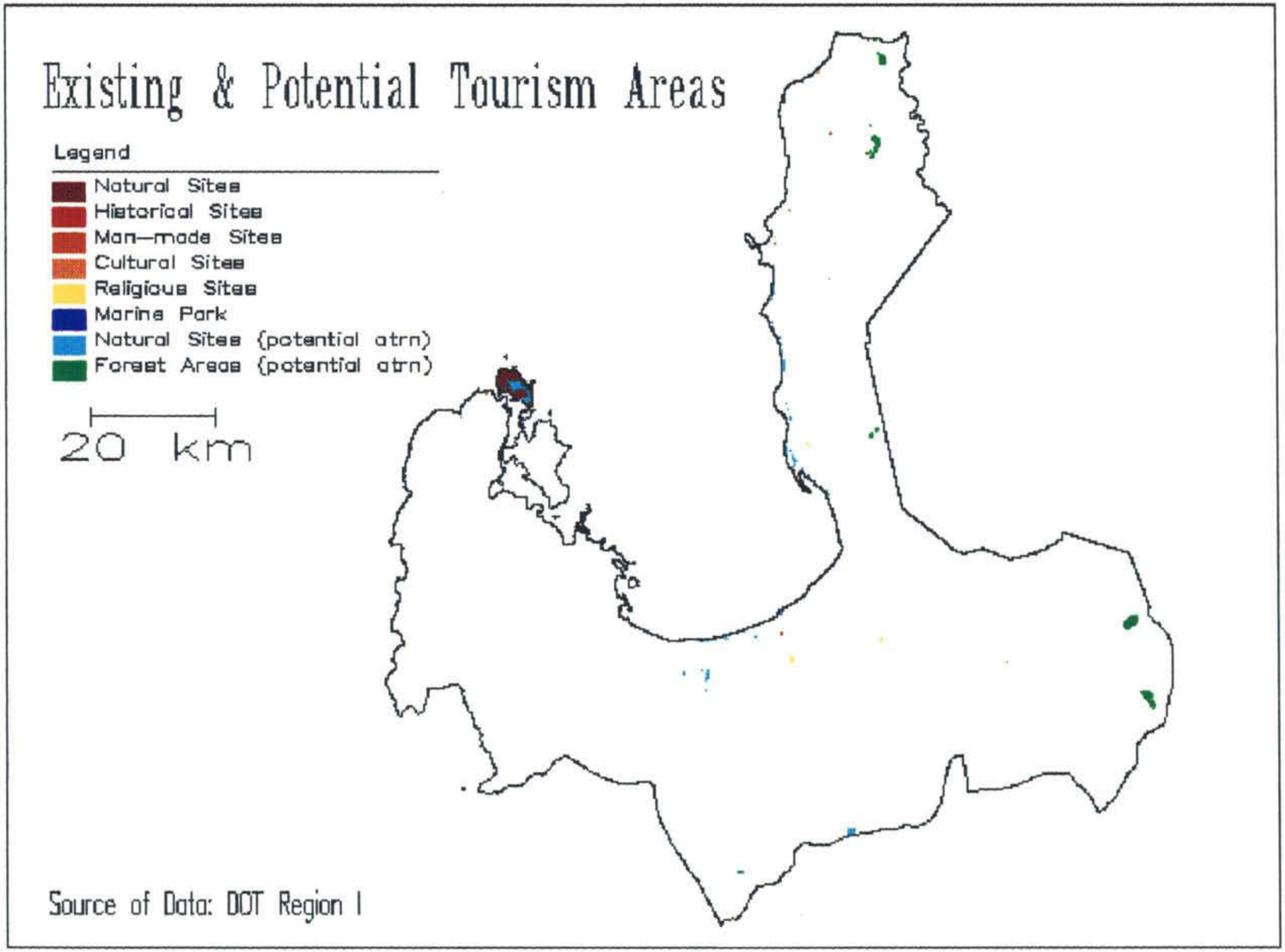
	Name of Establishment	DOT Classification	TC	Score	Rank
1	Agoo Playa Hotel	Class "AAA"	1	100	1
2	Acapulco Beach Resort	Class "AA"	2	80	2
3	Cresta del Mar Resort and Beach Club	Class "AA"	2	80	2
4	Bali Hai Beach Resort	Class "A"	3	60	3
5	Caba"a Beach Resort	Class "A"	3	60	3
6	Celeste Sea Breeze	Class "A"	3	60	3
7	Center Beach	Class "A"	3	60	3
8	China Sea Beach Resort	Class "A"	3	60	3
9	Coconut Grove Resort Bowls Club	Class "A"	3	60	3
10	El Caseron Beach Resort	Class "A"	3	60	3
11	Fisherman's Wharf Resort Club	Class "A"	3	60	3
12	Holiday Village and Beach Resort	Class "A"	3	60	3
13	Lazy "A" Beach Resort	Class "A"	3	60	3
14	Long Beach Resort-Hotel	Class "A"	3	60	3
15	Prime Island Resort	Class "A"	3	60	3
16	San Fabian Presidential Resthouse	Class "A"	3	60	3
17	Sierra Vista Beach Resort	Class "A"	3	60	3
18	Southern Palms Beach Resort	Class "A"	3	60	3
19	Sun and Sand Beach Resort	Class "A"	3	60	3
20	Windsurf Beach Resort	Class "A"	3	60	3
21	Ocean Deep	Sp. Interest	4	60	3
22	Dagupan Village Hotel and Sports Center	"Economy"	5	60	3
23	Pangasinan Village Inn	"Economy"	5	60	3
24	Plaza Hotel	"Economy"	5	60	3
25	Villa Estrella	"Economy"	5	60	3
26	Bagong Lipunan Lodge	Tourist Inn	6	40	4
27	Balingasay Perpetual Beach Resort	Tourist Inn	6	40	4
28	Carrille Terrace	Tourist Inn	6	40	4
29	Ciudad Fernandino Hotel and Restaurant	Tourist Inn	6	40	4
30	Golden Heaven	Tourist Inn	6	40	4
31	Hotel Mil Exel	Tourist Inn	6	40	4
32	Majoha Hotel and Restaurant	Tourist Inn	6	40	4
33	Maria Angela Inn	Tourist Inn	6	40	4
34	Maxime's By the Sea	Tourist Inn	6	40	4
35	Nel-ars Travellers Inn	Tourist Inn	6	40	4
36	Ocean View Lodge	Tourist Inn	6	40	4
37	Pangasinan Sea Breeze Resort	Tourist Inn	6	40	4
38	South Pacific Beach Apartel	Tourist Inn	6	40	4
39	The Last Resort	Tourist Inn	6	40	4
40	Y Foods & Inn	Tourist Inn	6	40	4
41	Guiamoy Lodge	Pension House	7	20	5
42	Las Villas Beach	Pension House	7	20	5
43	A & E Restaurant & Inn	Lodging House	8	20	5
44	Alaminos Travel Lodge	Lodging House	8	20	5
45	Bangsal Inn	Lodging House	8	20	5

TC = Type Class

Name of Establishment	DOT Classification	TC	Score	Rank
46 Bayview Hotel	Lodging House	8	20	5
47 Bayview Plaza Inn	Lodging House	8	20	5
48 Boulevard Hotel	Lodging House	8	20	5
49 Caliman Lodge I	Lodging House	8	20	5
50 D' Guesthouse at the End of the Road	Lodging House	8	20	5
51 D'Rose Inn	Lodging House	8	20	5
52 Family Beach	Lodging House	8	20	5
53 Gelymar Traveller's Inn	Lodging House	8	20	5
54 Hideaway Beach Resort	Lodging House	8	20	5
55 Hotel Cadena de Amor	Lodging House	8	20	5
56 Hotel Casa Blanca	Lodging House	8	20	5
57 Hotel Victoria	Lodging House	8	20	5
58 Jasmin Lodge	Lodging House	8	20	5
59 Mandarin House & Restaurant	Lodging House	8	20	5
60 Marjo Travellers Inn	Lodging House	8	20	5
61 Miramonte Beach Resort	Lodging House	8	20	5
62 Monaliza Cottages	Lodging House	8	20	5
63 Nipa Hotel and Restaurant	Lodging House	8	20	5
64 Salanga's Compound	Lodging House	8	20	5
65 Sunset Bay	Lodging House	8	20	5
66 Sunset Beach Resort	Lodging House	8	20	5
67 The Mirage Beach Club	Lodging House	8	20	5
68 Urdaneta Inn	Lodging House	8	20	5
69 Vicar Hotel	Lodging House	8	20	5
70 Snow-White Drive Inn	Motor-Hotel	9	20	5

TC = Type Class


Resort Classification based on Standard
(Room Rates and Facilities)
Legend
Very High Standard
High Standard
Average Standard
20 km
Source of Basic Data: DOT Region I


Existing & Potential Tourism Areas
Legend
Natural Sites
Historical Sites
Man—made Sites
Cultural Sites
Religious Sites
Marine Park
Natural Sites (potential atrn)
Forest Areas (potential atrn)
20 km
Source of Data: DOT Region I

Conclusion and Recommendations

Through the GIS, the tourism potentials of the Lingayen Gulf have been assessed. It is shown that there is still quite a large potential area which can be developed for tourism to support the region's development thrusts, particularly that embodied in the NWLGQ. As tourism development and environmental quality are interrelated, it is pointed out that appropriate policies on tourist resort development have to be set in place to check the poor disposal/management of resort sewerage and the change in beach profile, to arrest coastal erosion and damage to resort infrastructure as well as for the protection of natural scenic, historical and cultural sites in the gulf area.

Finally, it is recommended that the predominantly supply-side (i.e. facility and sites) analysis be enhanced to include the demand side (e.g., tourist arrivals, occupancy rates, length of stay of tourists, tourist activities, etc.). It may also improve the study results to look into the potentials of other tourist activities, other than the sea-based activities, to broaden the tourism base of the region and to find out if there exists some geographic clustering or potential interlinkages of tourist zones.

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1992 Provincial Tourism Situationers for La Union and Pangasinan, DOT Region I, 1993

Sectoral Planning Guidelines for Tourism, HSRC/MHS, May 1982.

Assessment of Mangrove Areas and Site Identification for Reforestation in Lingayen Gulf area, Philippines

Z.N. Alojado[1], J.N. Paw[1], K. Q. Casuga[2]

Abstract

For more than half a century, mangrove areas in Lingayen Gulf area had been converted into brackishwater ponds for milkfish culture including other land uses. Large-scale conversion occurred after World War II. At present, the mangrove areas are patchy and mostly found along the periphery of rivers and some coastlines. In recent years, appreciation of mangroves for its ecological role in the coastal environment has increased considerably. Within Lingayen Gulf area, this resulted in attempts at mangrove reforestation. Such attempts, however, had been met with failure due to a number of factors including improper site selection. This paper presents a methodology for mangrove reforestation using geographic information systems.

Introduction

Mangrove is a critical resource found in coastal areas. Ecologically, it serves as nursery grounds for many species of fishes, crustaceans and various invertebrates as well as habitat for some wildlife. It also acts as buffer against strong wind, tidal currents, typhoon and other natural disturbances. Economically, mangrove is a major source of income for some coastal communities providing fuelwood, food and medicine (Paw and Chua 1991). Notable mangrove species found in Lingayen Gulf area are *Rhizophora* and *Avicennia.*

For many years, mangrove have either been unsustainably harvested or converted to fishponds and other land uses. In the Lingayen Gulf areas, large tract of mangroves had been converted into brackishwater ponds for milkfish culture since before World War II. Accelerated conversion, however, came after

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the war. Although mangrove areas come under the definition of public lands, many of these areas were either leased or offered for sale by the government for aquaculture purpose (Dannhaeuser 1986). At present, mangrove areas in Lingayen Gulf are patchy and mostly found along fishpond levees. Nipa (*Nypa fruticans*), on the other hand, is still extensive, possibly because of its more direct economic benefit.

In recent years, the ecological importance of mangrove have been recognized and strategies have been formulated to protect and/or manage the mangrove resources of the country including reforestation (Umali et al. 1986). Under the Lingayen Gulf coastal area management plan (NEDA, Region I 1992), rehabilitation of mangroves has been recommended as an alternative livelihood activity for coastal residence and at the same time improving the coastal environment through restoration of vegetation (mangrove) cover. There were several attempts at mangrove reforestation in the gulf area. Most have been failures. One of the factors is due to poor site selection (Paw et al. 1992). This paper assesses mangrove areas conversion in the gulf and to determine suitable sites for mangrove reforestation using geographic information systems.

Methodology

The 1990 land use and soil maps at scales of 1:50,000 to 1:100,000 were obtained from the Bureau of Soils and Water Management (BSWM). River systems, roads and elevation data were taken from 1:50,000 topographic maps published by the National Mapping and Resource Information Authority (NAMRIA). The maps were digitized using a digitizing package called TYDIG and imported into the geographic information system (GIS) software called SPANS. The elevation map was constructed through surface interpolation of spot heights and points from contour lines using the triangulated irregular network technique (Weibel and Heller 1991). Buffers along roads and river systems were constructed based on mangrove site selection. The criteria are based on guidelines set by the National Mangrove Committee of the Philippines (Cadiz, 1987, Zamora 1989, TS-PNMC 1986 and Melana 1987) (see Table 1). Tidal influence on rivers was based on salt intrusion data (BSWM 1985 and 1986). Buffers were constructed from the salt intrusion data representing the inland limit of seawater with salinity $\geq$10 parts per thousand. Some rivers do not have salt intrusion data and 1 to 1.5 km buffers were constructed based on visual examination of the rivers in 1:50,000 topographic maps. Most of these are minor rivers.

Mangrove suitability selection using the criteria in Table 1 was based on weighted map overlay of six thematic maps. The map weights were based on the degree of importance of each map layer relative to the other map layers and the total score normalized to 100. Other map layers such as settlements, existing

Table 1 Site selection criteria for mangrove reforestation areas.

Parameter	Criteria	Rank	Remarks
Soil texture	Clay, clayloam, silty	1	Suitable for most mangrove species
	clayloam, loam, silty loam, sandy loam		
	Sandy clayloam, sandy	2	Suitable for some non-mangrove species like coconut and *Casuarina*
Landuse	Grassland, shrubs,	1	Suitable since they are considered marginal lands
	marshland, saltbeds coconut		
Elevation	less than 3 meters	1	Suitable since these areas experience regular tidal inundation
Salt intrusion	<1.5 km distance	1	Suitable areas should be within 1.5 km distance from either seashore or tidally influenced rivers where salinity is within acceptable limit for mangrove
Roads	<5 km distance	2	Suitable sites should be far from busy roads to
	>10 km distance	1	minimize disturbance from existing economic activities
Water sources	<1.5 km distance	1	Sites should be located near water sources for ecological purpose

mangrove and fishpond areas, and rivers without buffers were used to sieve through the mangrove suitability map and potential reforestation areas were determined.

Area analysis was conducted to estimate the areal extent of potential sites for mangrove reforestation. Area cross tabulation analysis was also undertaken to determine potential reforestation areas with respect to its proximity water sources (e.g. shore).

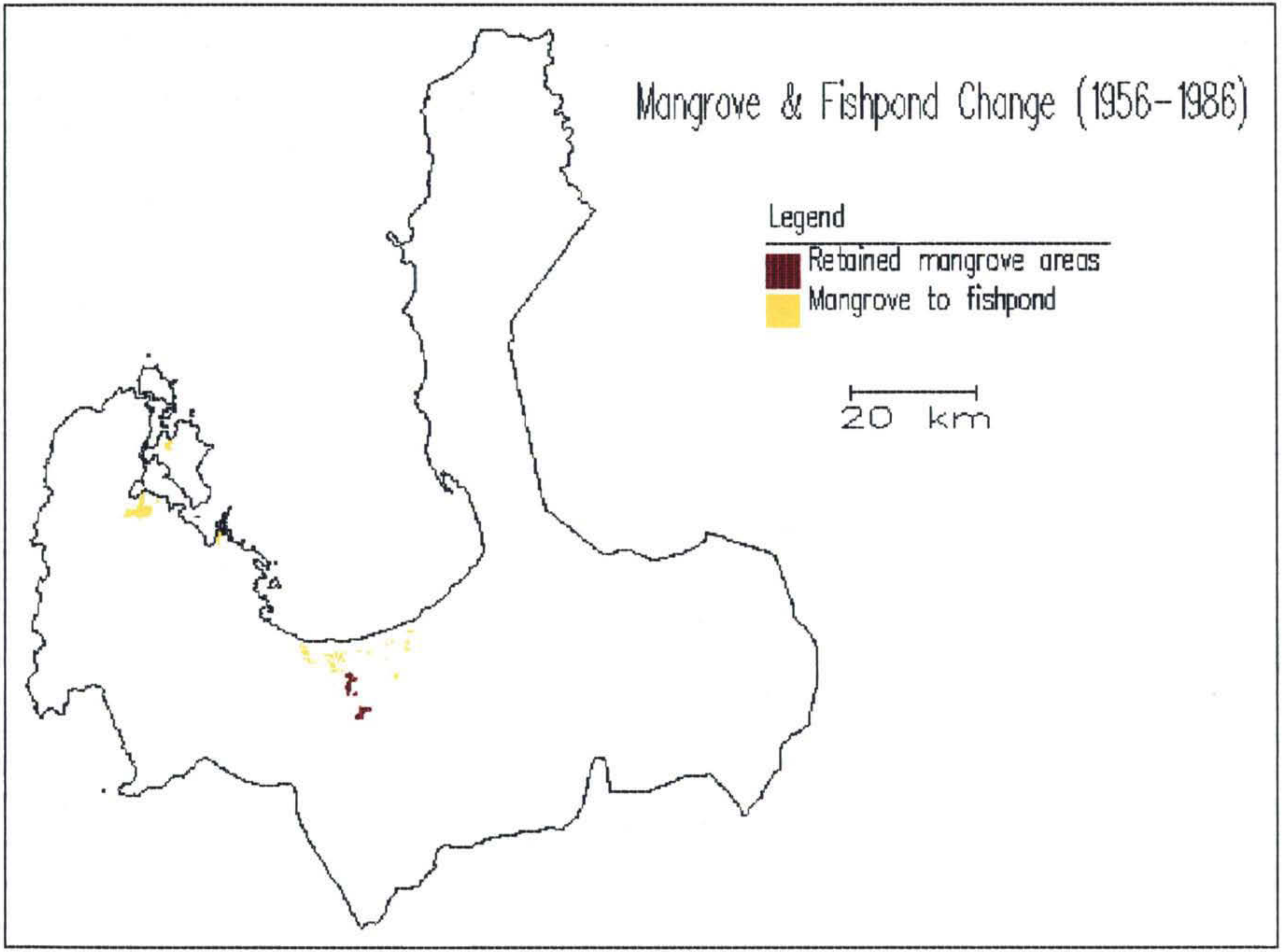
Land cover change analysis for mangrove, particularly conversion to fishponds was made using data sets from three periods 1950, 1986 and 1990. The 1950 data were digitized from 1:50,000 topographic maps published by the United States Army Map Service derived from aerial photographs. The 1986 (1:250,000 scale) and 1990 data were segmented from the land use maps produced by BSWM.

Results and Discussion

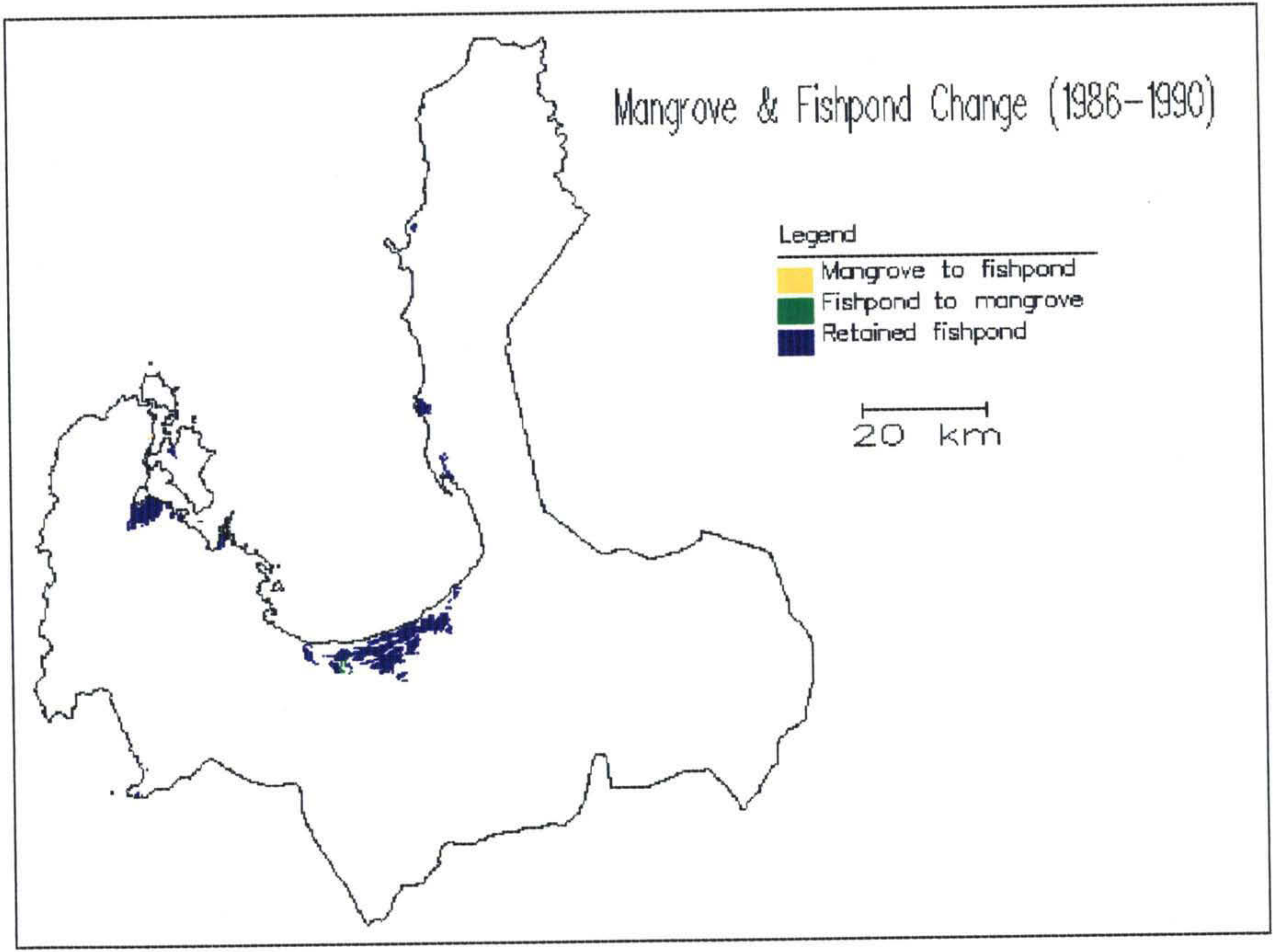
The mangrove areas in Pangasinan and La Union are patchy, particularly those located within the Lingayen Gulf area. Nipa which is closely associated with mangroves occur in large tract but conversion was limited presumably because it has direct economic benefit than mangrove. Nipa is a multipurpose resource where the fronds are used for roof thatching, its nectar for vinegar and the fruit for food. In this study, mangrove and nipa areas are pooled. According to Zamora (1987), the mangrove ecosystem serves several functions: buffer against storm surges and strong winds; habitat for many economically important species of animals and plants; contributor to nearshore and offshore productivity through leaf litter; and contributor to land formation by trapping debris, filtering terrestrial runoff and organic matter.

Conversion of mangrove areas into fishponds started before World War II and continued until the mid-1980s. Dannhaeuser (1986) reported that government sold or leased mangrove areas in Western Pangasinan after the war for fishpond development. Among the coastal resources, mangroves have been regarded as economically marginal with high conversion priority into economically more productive land use such as fishponds, ricefields and coconut. In Lingayen Gulf, the major conversion category is fishpond notably within Pangasinan plain.

Land use change analysis by comparing the spatial distribution of mangroves in the 1951 topographic maps and 1986 and 1990 land use maps showed that about 5,594 ha have been converted to fishponds and other land uses within a span of 40 years. A substantial portion of this conversion occurred before 1987. Table 2 shows the areal extent of mangroves and fishponds during



Mangrove & Fishpond Change (1956-1986)
Legend
Retained mangrove areas
Mangrove to fishpond
20 km


Mangrove & Fishpond Change (1986–1990)
Legend
Mangrove to fishpond
Fishpond to mangrove
Retained fishpond
20 km

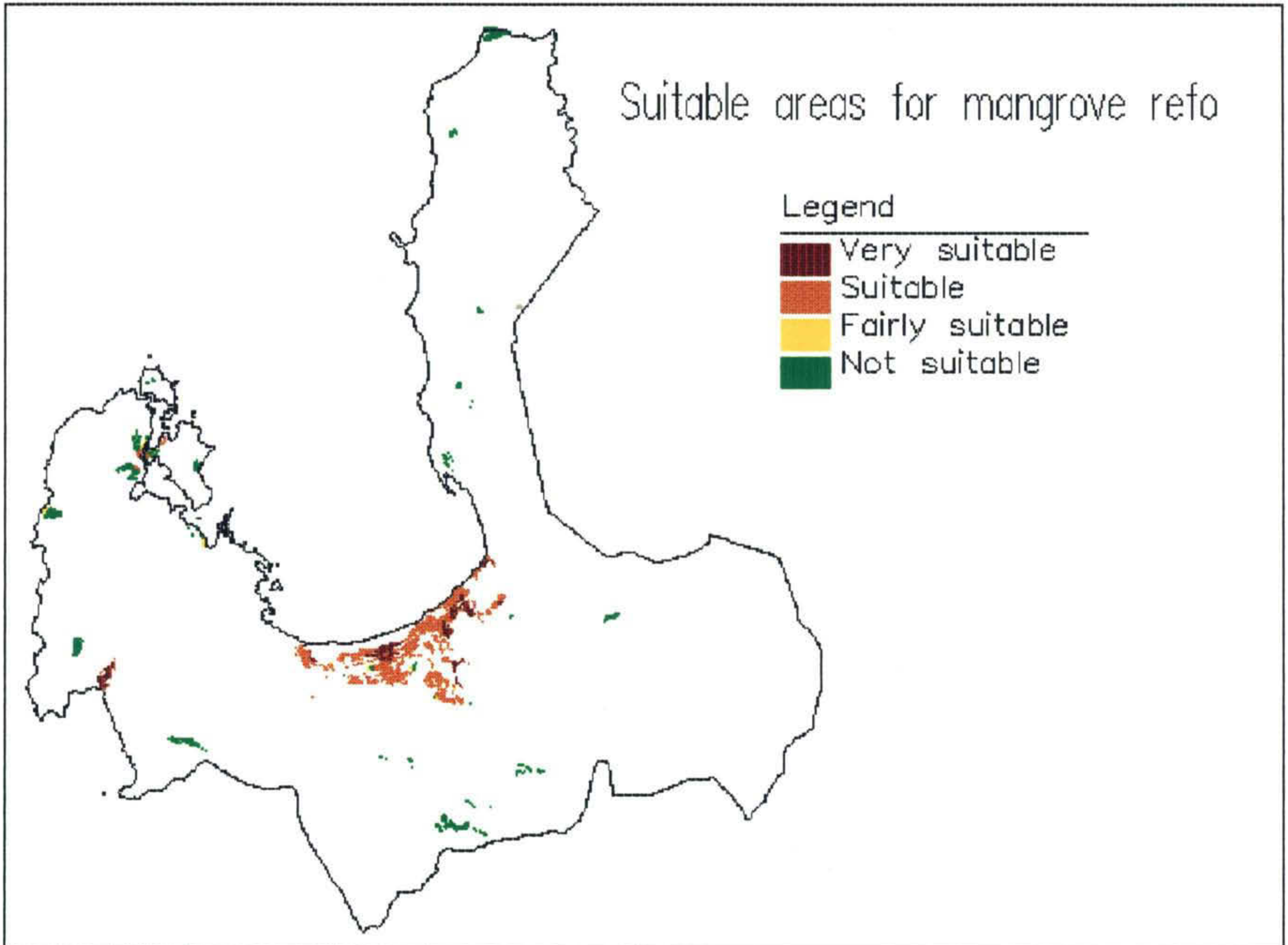
the three periods. Conversion to fishpond accounts for about 34% of the 1951 mangrove cover in Lingayen Gulf within the past 40 years.

Although mangroves areas are public domain, the government have either sold or leased such lands for conversion to other land uses, especially fishponds. Efforts at conservation have been minimal. In 1975, the Revised Forestry Code (Presidential Decree No. 705) prohibits the conversion of mangroves along the shorelines. Amendment to PD 705 included the establishment of buffer zones of at least 50 m in width and 20 m for both sides of river channels/banks and 100 m inward along shorelines (Department of Environment and Natural Resources (DENR) Administrative Order (AO) No. 13). In 1976, the Philippine National Mangrove Committee was created to conserve and manage the mangrove resources of the country (Paw and Chua 1991, TS-PMC 1986). Under DENR AO 15 known as the "Regulations governing the utilization, development and management of mangrove resources," conversion of mangrove areas into fishponds are no longer allowed. The regulations also provide for the conservation and management of mangrove resources including reforestation.

Mangrove reforestation in the Lingayen Gulf area has been pursued by DENR through its regional office. Since the late 1980s, mangrove reforestation in the gulf area have been attempted with minimal success. Most projects were contracted to either individuals or groups with very minimal technical backstopping. Moreover, the government staff charged with reforestation programs had poor technical expertise on mangroves. In addition to institutional problems, other factors contributed to the failure were destruction by typhoons, earthquake (i.e., liquefaction) and poor growth of seedlings.

The areas identified for mangrove reforestation were not extensive and the selection process was technically inadequate (Paw et al. 1992). This study provides a more systematic method of site selection for mangrove reforestation using GIS. The GIS technique used is weighted map overlay analogous to the multicriteria evaluation technique called weighted summation (Voogd 1983). The criteria considered in the map overlay process are based on the guidelines set by the Philippine National Mangrove Committee (TS-PNMC 1986) and the works of Cadiz (1987), Zamora (1989) and Melana (1987).

Analysis showed that about 4,109.5 ha are considered potential suitable areas for mangrove reforestation. About 3,703.2 ha met all the selection criteria list in Table 1. The resulting area analysis is shown in Table 3. Most of the potential suitable areas are found in the municipalities of Calasiao, San Carlos, San Jacinto, Mangaldan and San Fabian (Fig. 1). Based on ocular inspection of aerial photographs prepared by NAMRIA which were taken in late 1990 and early 1991, areas under suitable category for mangrove reforestation (combination of categories 1 and 2) are within marginal lands. A large tract


Suitable areas for mangrove refo
Legend
Very suitable
Suitable
Fairly suitable
Not suitable

located in the municipalities of Calasiao and San Carlos, however, are ricefields. Closer examination showed that the area is bounded by the tributaries of the Agno River and Patalan-Sinocalan River. Because the weights of the river and salt intrusion maps were high, the total suitability score of the area increased even if the land use category (ricefield) score was very low (-1.0). There is no ground information whether the area suffers from periodic salt intrusion problem. At any rate, since this area is quite far from the shore, it would be better to retain its current land use status than converting it to mangrove area or fishponds. In Table 4, about 757.4 ha of the potential suitable areas (category 1 and 2) are within 1.5 km distance from the shore of which 50% are located 500 m from the shore.

At present, mangrove reforestation activity is not vigorously pursued due to past poor performance. Inadequate technical knowledge on mangrove ecology among DENR staff at the regional level who are tasked to implement reforestation program makes it difficult to carry out the mandate under AO 13. Systematic approach on mangrove site selection such as the use of GIS can be a step towards ensuring success. Although the procedure requires a fair degree of technical expertise, this can be achieved through an inter-agency collaboration such as between DENR and NAMRIA (Department of Defense); NEDA Region I Office or BSWM (Department of Agriculture) as well as with academic institutions (Institute of Biology, University of the Philippines). NAMRIA, NEDA Region I and BSWM have GIS capability and some technical expertise in resource assessment while the Institute of Biology has some experts on mangrove ecology and biology. The initial task of refining the parameters for site selection using GIS can be provided by such an inter-agency collaboration.

The resolution of the results of this study is rather low but sufficient at the planning level. The procedure certainly requires further refinement (e.g., inclusion of other parameters that can determine the species to be planted, updated land use map, detailed soil data and socioeconomic factors, etc.) in order that the result will have a fair degree of accuracy with respect to actual ground conditions, especially for the purpose of implementation. Once such procedure has been tested and standardized, it can be disseminated to the regional DENR office for further assessment at the local level. The approach should not be restricted to the Lingayen Gulf area only but to include strategic areas of the country as well.

Conclusion

The mangrove resources of Lingayen Gulf area are highly disturbed and patchy. Substantial areas of mangroves had been converted into fishponds over the past 40 years. With increasing recognition of the ecological importance of mangroves by the government, several reforestation projects had been attempted

Table 2. Landuse change for mangrove areas in Pangasinan & La Union in km^2.

Legend	1951	1986	1990
Mangrove	58.2144	11.634	2.270
Fishpond		137.671	145.890
Mangrove converted to fishpond		19.6289	0.000
Fishpond converted to mangrove		0.0000	0.4033

Table 3. Area analysis of the potential suitable sites for mangrove reforestation.

Category	Area (%)	Area (km^2)
Very Suitable	0.93	9.262
Suitable	2.78	27.770
Fairly Suitable	0.41	4.063
Not Suitable	3.84	38.406
Others (Excluded)	92.04	920.079

Table 4. Area cross tabulation of potential suitable areas for mangrove reforestation within proximity to the shore (km^2).

Category	0.5 km	1.0 km	1.5 km	Total
Very Suitable	0.45	0.672	0.523	1.240
Suitable	3.301	2.091	0.941	6.334
Fairly Suitable	2.181	0.642	0.000	2.823

in various coastal areas of Pangasinan and La Union but some with dismal result. Technical and institutional factors contributed to such failure including natural disasters. Selection of sites for mangrove reforestation was poor and relied on insufficient qualitative data (e.g., interview of old fisherfolk). This study provides a site selection procedure using GIS which considers biogeographical factors. The areas for mangrove reforestation is substantial at 4,109.5 ha with 757.4 ha located within 1.5 km distance from the shore. Most of these areas are located in the municipalities of San Fabian, Mangaldan, San Jacinto, Calasiao, San Carlos and Bolinao.

Refinement of the GIS procedure for implementation would require more detailed data at higher resolution including socioeconomic information on coastal communities. It is recommended that an inter-agency collaboration should be established to refine and standardize site selection procedure for mangrove reforestation which will then be utilized by regional agencies implementing mangrove reforestation projects.

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Land Resource Assessment for Brackishwater Aquaculture Development in Lingayen Gulf Area, Philippines

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Abstract

Brackishwater aquaculture is an important economic sector in Region I. For the past 60 years, extensive areas of mangrove and ricefields have been converted to brackishwater ponds, especially in Pangasinan. Between 1986 and 1990, some 3,072.8 ha of ricefields and 1,217.5 ha of inland swamps have been converted to brackishwater ponds. About 34% of mangrove areas were converted to aquaculture between 1951 and 1990.

Aquaculture in Lingayen Gulf area is constraint by low production, especially milkfish due to slow adoption of better farm management practice and poor farm layout. Although intensification rather areal expansion has been recommended in the Lingayen Gulf coastal area management (CAM) plan, identification of suitable sites would be useful for alternative livelihood projects aimed at marginal coastal communities. Also, such areas could be developed by the government for training and demonstration farms to disseminate improve culture practices. Potential brackishwater aquaculture areas identified in this study using geographic information systems has an aggregate total of 2,684.4 ha. Portion of the potential areas is reallocated for mangrove reforestation so that about 141 ha remain for aquaculture.

Introduction

The Lingayen Gulf area is one of the important aquaculture production areas in the Philippines. Milkfish and shrimp production from brackishwater ponds contributed about 11% of the annual national aquaculture production. Oysters production was about 7,600 t in 1991 (2.45% of national production) which came largely from Pangasinan. Other mariculture activities like seaweed culture and fish cage culture have minimal contribution to total production

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compared to brackishwater aquaculture but foreign exchange earnings are significant. The brackishwater farms of Lingayen Gulf are either under private ownership or long-term lease from the government (Dannhaeuser 1983). Many of the aquaculture farms are small size (<5 ha) largely due to partition through inheritance (GOPA 1983). Most owners leased their farms instead of operating these themselves. Usually, aquaculture is a secondary source of income (Paw and Palma 1991).

Brackishwater aquaculture is constrained by low production due to poor management practice (Palma 1989, NEDA Region I 1992). Thus, areal expansion would not be an appropriate strategy to increase production but rather the improvement of management practice including farm layout. Compare to agriculture, aquaculture is a profitable business venture, particularly in areas affected by saltwater intrusion. Dannhaeuser (1983) reported that some ricefields in the municipality of Dagupan had been converted to brackishwater ponds due to salinization. In recent years, the high profitability of shrimp farming has also encouraged the conversion of ricefields to shrimp farms as well as switching from milkfish to shrimp culture. The extent of conversion is not known. In this study, land use changes relative to brackishwater aquaculture development in Lingayen Gulf area are assessed to estimate the magnitude of change. In addition, indiscriminate land conversion to brackishwater ponds should be discouraged. With proper site selection process, such conversion can be regulated. Although areal expansion for brackishwater aquaculture should be minimized, identification of potential areas would also be useful in terms of allocating the sites for alternative livelihood projects targeting coastal fishermen as well as demonstration and training farms within Northern Luzon for the government to disseminate improve culture practices.

Methodology

There are two aspects of this study using geographic information system (GIS). One deals with land use change relative to brackishwater aquaculture development and the other, on site selection for potential areas. The GIS software used in this study is called SPANS developed by INTERA TYDAC of Canada.

Thematic maps from the Bureau of Soils and Water Management (BSWM) such as the 1986 and 1990 land use maps, soil texture and physiography were digitized and imported into SPANS. The map scales ranged from 1:50,000 to 1:100,000 (Universal Transverse Mercator). The 1981 forest condition map (1:250,000) was provided by the Forestry Management Bureau (FMB) of the Department of Environment and Natural Resources (DENR). River systems and roads were digitized from 1:50,000 topographic maps published by the National Mapping and Resource Information Authority (NAMRIA). Existing fishponds were extracted from three sources - 1990 land use map, 1990 Landsat Thematic Mapper and 1990/91 aerial photographs. The latter two were used to update the 1990 land use map.

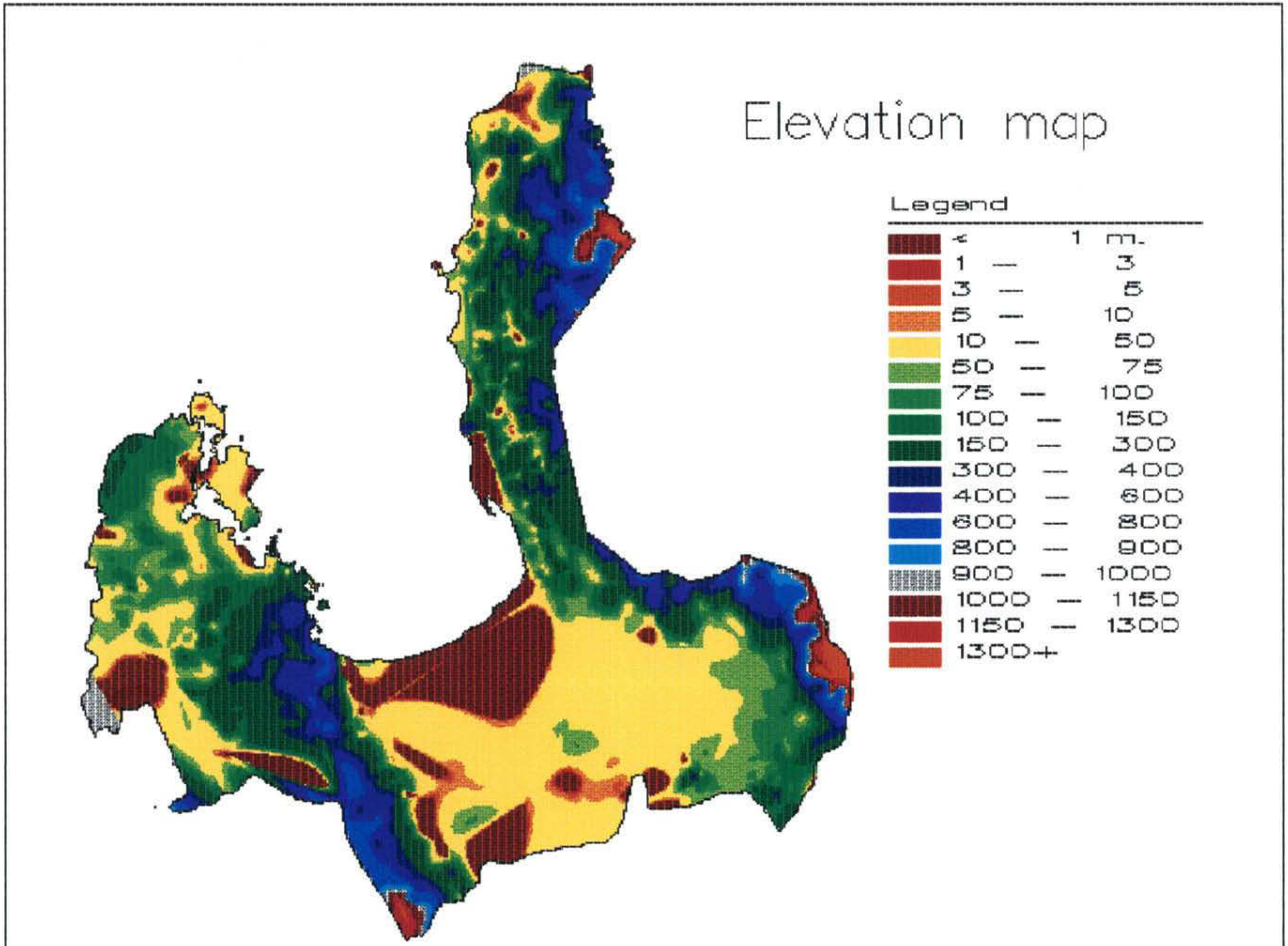
An elevation map was constructed from digitized spot heights and contour lines using a surface interpolation technique called triangulated irregular network (Weibel and Heller 1991). Buffers were constructed along roads and river systems. Salt intrusion data were taken from BSWM (1985, 1986). The length of the buffer represents the inland extent of saltwater with salinity $\geq$10 parts per thousand. For rivers (minor) without saltwater intrusion data, 1.0 to 1.5 km buffers were constructed based on ocular examination of the topographic maps. Also, buffers were constructed along river banks and shoreline based on policy (DENR Administrative Order (AO) 13).

Land use change analysis was conducted by two map overlay process such as two land use/cover maps of different year and selectively determine areas of change per specific category (e.g., land use category). Area and area cross tabulation were conducted with municipality map for Pangasinan and La Union.

Brackishwater aquaculture site selection criteria are summarized in Table 1 and taken from various works (Adisukresno (1982), Hechanova (1982), Khoo and Wuan (1982) Menasveta (1982), dela Cruz (1983) and Poernomo (1990). Seven map layers were weighted and overlaid. The overlay process is analogous to the multicriteria evaluation technique called weight summation (Voogd 1983). The weights were derived from ranking each map relative to their perceived importance in the pond culture of the 4 species (milkfish, shrimp, siganids and seabass). The total score per map was normalized to 100 and used as weight. Potential areas were determined through exclusion certain existing land uses (settlements, mangroves and fishponds), roads, river systems and ecozones. Area analysis was conducted on the resultant map including proximity to water sources.

Results and Discussion

Brackishwater aquaculture, particularly milkfish culture is a traditional practice in the Lingayen Gulf area dating back before World War II. Accelerated development occurred after the war and well into the 1980s, especially for shrimp culture. Substantial mangrove and nipa swamps including ricelands were converted to aquaculture farms (Dannhaeuser 1986, Paw and Palma 1991). At present, aggregate total area of brackishwater ponds (finfish and shrimp) is 14,589 ha with about 1,566 ha in La Union and the rest in Pangasinan. Brackishwater ponds are extensively located in the municipalities of Binmaley, Dagupan, Bani, San Carlos, Lingayen and Alaminos in Pangasinan and in the



Elevation map
Legend
< 1 m.
1 — 3
3 — 5
5 — 10
10 — 50
50 — 75
75 — 100
100 — 150
150 — 300
300 — 400
400 — 600
600 — 800
800 — 900
900 — 1000
1000 — 1150
1150 — 1300
1300+

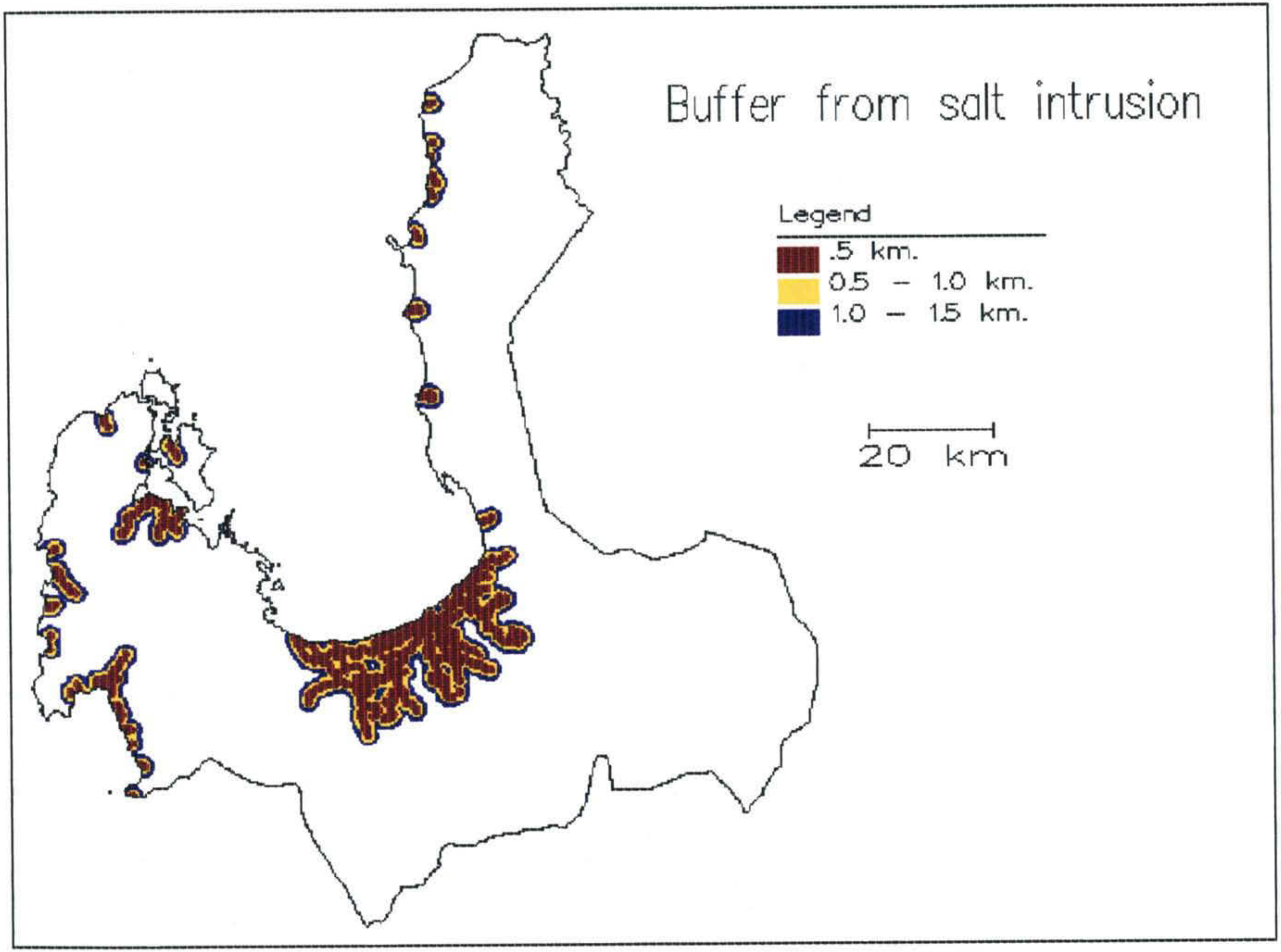

Buffer from salt intrusion
Legend
.5 km.
0.5 - 1.0 km.
1.0 - 1.5 km.
20 km

Table 1. Site selection criteria for brackishwater aquaculture areas. The factors presented as map layers are used in the overlay process.

Factor (Map Layer)	Criteria
Soil	This refers to soil texture. Clay, clay loam and silty clay loam are excellent to good soil types for brackishwater ponds such as for dike construction. Sandy loam (at last 35% sandy), loam or silt with clay size fraction (<0.005 mm) content of at least 20% are considered fairly good soil types. Hydrosol is classified as good soil type and has high clay content but is highly acidic. Ponds built with this soil type require liming and repeated flushing to neutralize acidity. For extensive shrimp culture, loamy to sandy pond bottom are preferred. For semi-intensive and intensive systems, sandy clay loam to sandy loam are better.
Physiography	Tidal flats are excellent areas for siting fishponds because they are regularly exposed to tidal fluctuations. Beaches are classified as good to fairly good category depending on soil types (at least 10% sand is good). Alluvial areas can be fairly good depending on soil types and provided they are within 5 km distance from the shoreline or 3 km distance from rivers with tidal influence.
Elevation	Ponds that will rely on gravity for drainage or tides for water exchange should be sited between 0 to 1.8 m from the tidal datum (mean low water, MLW) with a slope of 0-3% (excellent category). In general, coastal areas with 0-8% slope is suitable but the elevation should be below 5 m from tidal datum. Ponds sited at elevation higher than 1.8 m will require pumping.
Land Use	Priority areas for conversion to brackishwater ponds are marginal lands (grass lands, swamps), coconut plantations and unproductive agricultural lands including degraded mangrove areas (alienated). Areas gazetted for conservation (national parks) including mangroves and reforestation are excluded. Also paddy fields are excluded or given a low score depending on their proximity to the coast. Settlements generally assume a linear development which is difficult to demarcate. Only the major settlements have been demarcated and a 1 km buffer established. As much as possible, ponds should be sited away from settlements to minimize pollution from domestic wastes.
Roads	Accessibility to roads is important as delivery of farm products and supplies will incur some cost per unit distance between farm and market. Suitable sites should be within 3 km from village or private roads and within 10 km from municipal, provincial or national roads. Buffers at 0 to 5 km distance from such roads are used in the overlay process.
Water Source	Aquaculture sites should be located within proximity to good water sources either from the seashore or from rivers (both freshwater and saltwater). Culture systems that require low salinity (below 30 ppt) would be best sited within proximity to rivers. Proximity to water sources is a combination of two map layers: distance from rivers and shoreline represented as buffers at 0, 1, 2, 3, 4, 5 km distance and are used in the overlay process.
Eco-zones	For ecological considerations and as setback lines for development, a 40-m buffer is established along river systems and 100-m buffer along the shoreline. Apart from existing land use considerations, these strips of lands could be planted with mangroves as protection against wave action.
Salt Intrusion	This layer refers to the extend of saltwater intrusion inland through the river systems. It is used to delimit the inland boundary where brackishwater ponds can be sited. It was constructed from conductivity measurements along the length of the river and converted to salinity values (minunum - about 10 ppt).

municipalities of San Fernando, Aringay and San Tomas in La Union.

Land use change relative to fishponds was documented between 1980 to 1990 and 1986 to 1990. Based on In the former, brushland was converted into fishponds in the municipalities of Sual (38.8 ha), Bani (50.8 ha) and Anda (1.5 ha). It is also possible that there was mangrove conversion into fishponds but since the 1980 data was examining upland forest cover, its coverage of coastal forest including mangroves was limited. Hence, there was no detectable cover change for mangroves. Comparing the mangrove cover of 1951 topographic map with the 1990 land use map, 34% of mangrove (mixed mangroves and nipa) was converted to fishponds over the past 40 years (Alojado et al., this volume).

In the assessment of cover change between 1986 and 1990, several land use categories were converted into fishponds including shrimp ponds. Although the latter is not documented in the 1990 land use map, personal observations record some ricefield conversion into shrimp ponds. Significant areas of ricefields had been converted into brackishwater ponds (3,072.8 ha) followed by swamplands (1,217.50 ha). Regarding built-up areas, the areal extent of conversion was 71.26 ha. Actual conversion may be unlikely. It is possible that some barelands or open areas adjacent to settlements were categorized as built-up areas which were later developed into fishponds. Extensive ricefield conversion occurred in the municipalities of Luna (118.01 ha) and Sto. Tomas (126.98 ha) in La Union and Dagupan (285.3 ha), Binmaley (413.8 ha), San Carlos (170.3 ha), Lingayen (490.0 ha), Labrador (210.6 ha), Alaminos (171.8 ha), Infanta (194.2 ha) and Bani (409.3) in Pangasinan. The area analysis of land use change assessment between 1986 and 1990 is shown in Table 2.

It is well documented that the problem affecting the brackishwater (milkfish) pond culture industry of Pangasinan and La Union is due to poor management practice (Palma 1989, GOPA 1983, Chong et al. 1984). Production could be enhanced to yield an average of 2,000 kg/ha/yr if modern culture techniques are applied including the use of farm inputs such as fertilizers. Unfortunately, culture techniques employed by most pond operators are very traditional yielding less than 1,000 kg/ha/yr for milkfish ponds. In addition, fishpond operation is often a secondary occupation so that adequate attention is not given to increasing production (Dannhaeuser 1983). Under the coastal area management (CAM) plan of Lingayen Gulf, one of the suggested strategies is to intensify brackishwater aquaculture production instead of expansion (NEDA Region I 1992). A recommended project to implement such strategy is to construct a saltwater canal across some fishponds to enhance access to good seawater and improve production.

Although the CAM plan has such recommendation, it would still be important to determine whether brackishwater aquaculture can still expand in the Lingayen Gulf area with the aim at using such areas for alternative livelihood

Table 2. Area analysis of the 1986 to 1990 land use change relative to brackishwater aquaculture development.

Land Use Change to Fishpond	**Area (%)**	**Cumm Area**	**Area (ha)**
Grassland (>90% dominant)	1.76	1.76	115.0
Ricefield, irrigated	47.03	48.79	3,072.8
Shrubs	6.93	55.71	452.6
Coconut	3.13	58.85	204.7
Built-up Areas	10.91	69.75	712.6
Sugar cane	0.23	69.98	14.9
Grassland (70-90^ dominant)	2.72	72.70	177.8
Inland swamps	18.63	91.34	1,217.5
Others	8.66	100.00	566.1
Total	100.00		6,534.0

projects for coastal communities as well as government training and demonstration farms for improved culture techniques/management. Also, such process could be used to delimit conversion to nonproductive areas.

Based on the result of area analysis, 2,684.40 ha are suitable for brackishwater aquaculture expansion (Table 3). Nearly 99% of the suitable sites are located within 1.5 km from rivers. A large part of this area is situated in the municipalities of Dagupan, San Fabian, Calasiao and Mangaldan which are crisscrossed by rivers.. As to its proximity to the shore, suitable areas are about 560.20 ha.

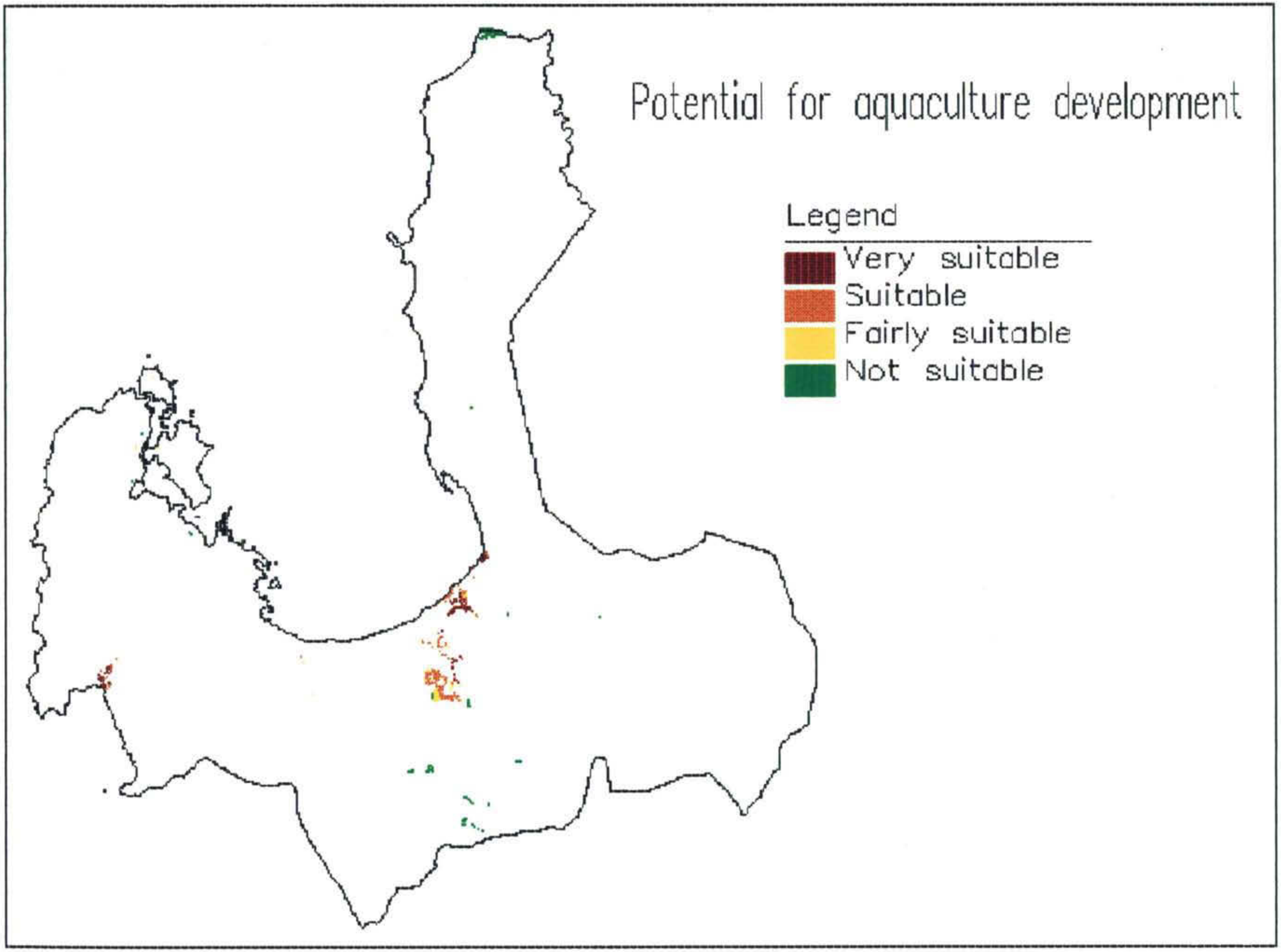
Under DENR AO 15, fishpond development (conversion) will be allowed only in denuded mangrove areas already zonified for aquaculture. It also covers mangrove reforestation. Because of the importance of mangroves and its patchiness along the gulf, the CAM plan recommended for mangrove reforestation (see Alojado et al., this volume). Thus, suitable areas identified for brackishwater aquaculture is being reallocated for mangrove reforestation, particularly those areas located along rivers and shoreline. Hence, about 141 ha of suitable aquaculture sites remain. Table 4 shows the adjustment for mangrove reforestation.

Limited ocular examination was conducted on the potential areas identified in this study. Based on site visits in San Fabian-Dagupan areas and the use of aerial photographs taken after the July 1990 earthquake, some of the potential suitable sites were in marginal areas which can be developed for aquaculture. Ground measurement, however, was not conducted.

Conclusion

Brackishwater aquaculture is an important economic sector in Region I, especially Pangasinan and La Union. For the past 60 years, significant land uses, particularly mangroves and ricefields, have been converted to brackishwater ponds. About 3,072.8 ha of ricefields and 1,217.5 ha of inland swamps were converted between 1986 and 1990, respectively to brackishwater ponds. For mangroves, about 34% were converted since 1951. Presently, mangrove conversion to aquaculture is not allowed.

Aquaculture production (milkfish) in Lingayen Gulf area remains low (<1,000 kg/ha/yr) despite its long history. Adoption of modern culture techniques and improvement of farm layout has been very slow. Thus, intensification would be an appropriate strategy to increase production rather than expansion of culture areas. Despite this situation, it would still be useful to determine potential suitable sites to be used in alternative livelihood projects for marginal coastal communities as well as training and demonstration plots.



Potential for aquaculture development
Legend
Very suitable
Suitable
Fairly suitable
Not suitable

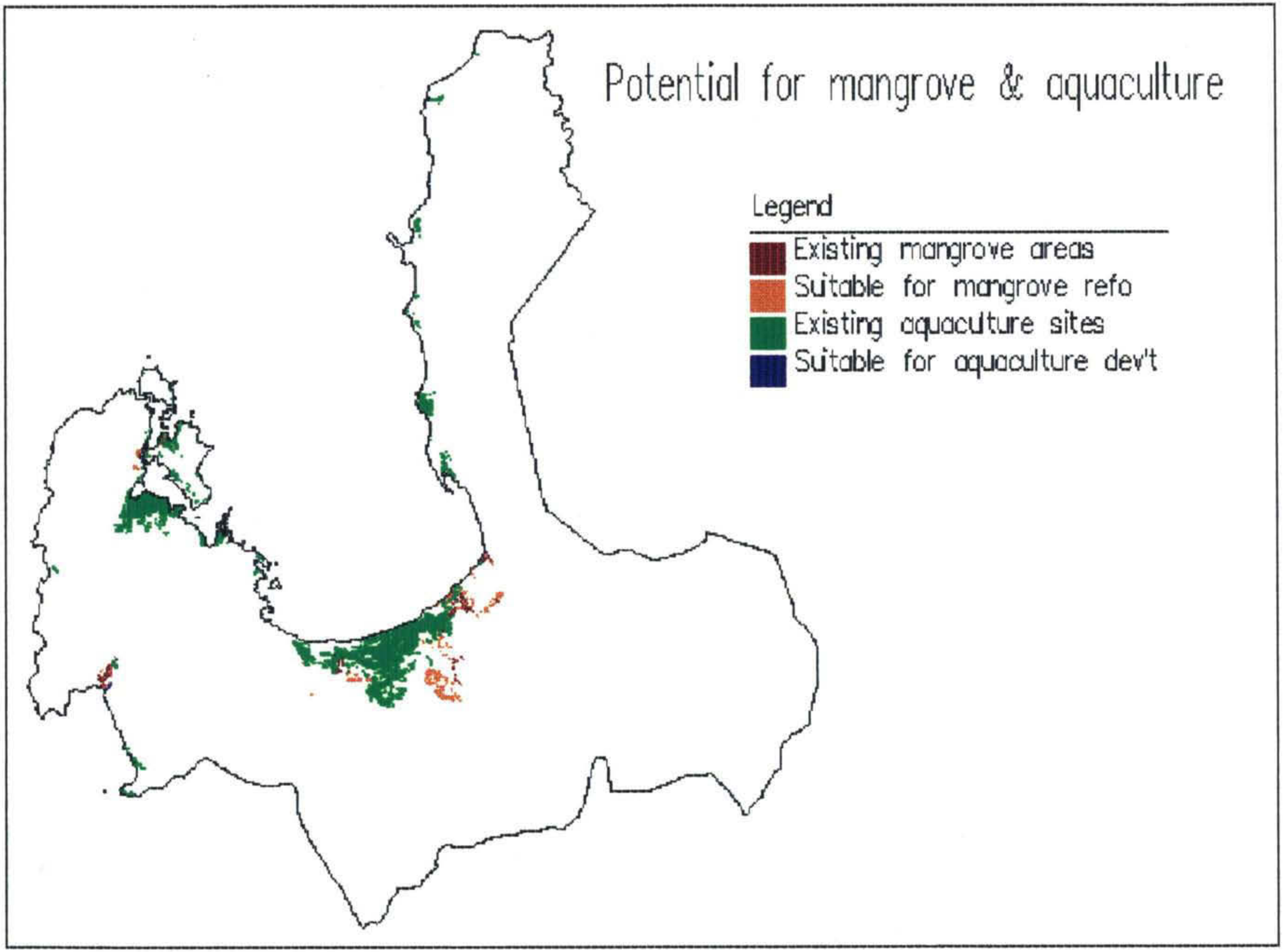

Potential for mangrove & aquaculture
Legend
Existing mangrove areas
Suitable for mangrove refo
Existing aquaculture sites
Suitable for aquaculture dev't

Table 3. Area analysis of potential brackishwater aquaculture sites.

Category	Area (%)	Area (ha)
Very Suitable	0.98	942.6
Suitable	1.81	1,741.8
Fairly Suitable	0.52	497.4
Not Suitable	1.10	1,060.6

Area analysis (ha) of potential sites within proximity to the shore.

Category	0.5 km	1.0 km	1.5 km	Total
Very suitable	26.9	86.6	79.2	192.7
Suitable	194.2	91.1	82.2	367.5
Fairly suitable	70.2	7.5	13.4	91.1

Area analysis (ha) of potential sites within proximity to the shore.

Category	0.5 km	1.0 km	1.5 km	Total
Very Suitable	902.3	35.9	4.5	942.6
Suitable	1,616.3	85.1	26.9	1,728.4
Fairly Suitable	37.3	265.9	113.5	416.8

Table 4. Relocation of Potential Brackishwater Areas for Mangrove Reforestation.

Category	Total Aquaculture Potential Areas (ha)	Overlap with Mangrove Potential Areas (ha)	Remaining Potential Aquaculture Areas (ha)
Very Suitable	942.6	935.1	7.5
Suitable	1,742.8	1,607.3	134.5
Fairly Suitable	497.4	231.5	265.9

Adjustment to Potential Mangrove Reforestation.

Category	Potential Mangrove Areas (ha) (ha)	Adjusted Area for Mangrove Reforestation (ha)
Very Suitable	926.2	1,904.6
Suitable	2,777.2	4,572.5
Fairly Suitable	406.3	545.2

About 2,684.4 ha are suitable. Since conversion for mangrove reforestation is a priority as recommended in the CAM plan, suitable aquaculture sites determined has been reallocated for mangrove reforestation. Thus, only about 141 ha can be utilized for brackishwater aquaculture expansion.

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Technical Report part III

Geographic Information System for Coastal Area Management and Planning Project

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Canada

Technical Report

on the

Geographic Information Systems

Application for Coastal Area

Management and Planning,

Lingayen Gulf Area, Philippines

Part III

CONTENTS

Geographic Information Systems Applications for Coastal Area Management and Planning in the Lingayen Gulf Area, Philippines

Introduction

The provinces of Pangasinan and La Union border the 2,100 km^2 Lingayen Gulf in northwestern Luzon, Philippines. The area was the pilot site of the Association of Southeast Asian Nation/US Coastal Resource Management Program for its first regional attempt to promote integrated coastal area management (CAM). The output of the CRMP was a CAM plan aimed at the sustainable development of coastal resources in the Lingayen Gulf area. Significant multiple resource use conflicts pervade in the gulf area which the plan is trying to mitigate.

The completion of the CAM plan and its possible implementation by the National Economic and Development Authority Region I Office (NRO) will require substantial revision to respond to changes in the management area. This is particularly important in light of the current development thrust of the Philippine government to industrialize some areas in Region I and has not been adequately considered in the CAM plan. As such, information management, especially spatial data is needed in order to ensure timely formulation of management options for decision making and policy considerations relative to the development and management programs for the Lingayen Gulf area.

Geographic information systems (GIS) technology has been chosen as the most appropriate tool for spatial data management but this requires pilot testing to determine its suitability and relevance under local institutional setting. Thus. the Geographic Information Systems for CAM and Planning Project (GISCAMP) was implemented with the Lingayen Gulf area as the pilot site to address spatial data management as a complementary mechanism for efficient and timely utilization of information for decision making. The GISCAMP was a 2-year project (September 1991 - February 1994) funded by IDRC with ICLARM as the executing agency.

Rationale and Objectives

One of the recommended strategies of the CAM plan for the Lingayen Gulf is the development of a zonation scheme for both land use and water space utilization. On a broader context, the zonation scheme should consider the downstream impact of hinterland activities so that appropriate management options and policy actions can be formulated to deal with linked habitats such as

forests. Indeed, the CAM plan has addressed such issue with a proposal to rehabilitate the Upper Agno River System watershed (NEDA Region I 1992). The Agno River Basin largely drains into the Lingayen Gulf. Studies on the basin however, have been largely focused on water resource assessment for development purpose with very minimal consideration on the ecological aspect, particularly on the management and conservation of forests. In order to determine what actions to undertake with respect to the rehabilitation of the watershed, it is necessary to quantify the downstream impact of watershed activities such as land use changes in the basin and sediment yield. Thus, critical areas can be determined for rehabilitation activities.

The zonation scheme proposed in the CAM plan is essentially based on ecological and resource management considerations but more focus on the coastal waters component such aquaculture, mangrove rehabilitation, fisheries and marine critical habitats. The terrestrial component such as agriculture, forest land, industrial areas and tourism sites is not well defined. Impacts of development activities, both short- and long-term, for tourism, agriculture, industrialization and urban expansion remain to be assessed and incorporated into the zonation scheme.

The original objectives of the GISCAMP essentially emphasized on all aspects related to zonation but without considering a comprehensive zonation scheme and the impact of development pressures. In light of the recommendations of the CAM plan and recent development programs for the Lingayen Gulf area, the original objectives with respect to the application of GIS for CAM are modified to include a comprehensive zonation in the context of a 6-year development program.

Objectives

1. To evaluate coastal land use changes and marine space utilization with respect to fishing, commercial fry collection, marine parks, mangrove reforestation, aquaculture development, tourism, human settlements and artificial reef sites and their impacts using GIS.

2. To determine the sphere of influence of upland watershed activities in terms of sediment and pollutant influx into coastal areas and their impacts thereof using GIS.

3. To differentiate between natural and anthropogenic changes in the coastal zone, where possible, to pinpoint areas of intense human activities so that appropriate management guidelines can be instituted and to delineate areas for conservation.

4. To develop a zonation scheme for the Lingayen Gulf areas that is consistent with the principles of sustainable development.

5. To establish a databank on spatial and attribute information relevant to CAM and planning at the pilot site.

Methodology

To meet the above objectives, the terrestrial and water components are divided into sectors represented as activities. There are 9 activities with Activity 9 as the integration of Activities 1 to 8 and the development programs for the Lingayen Gulf. The 9 activities are:

Activity 1	*Impact of upland watershed and lowland land use activities on the coastal zone.*
Activity 2	*Impact of human settlement development and expansion on the coastal area.*
Activity 3	*Delineation of fishing zones in Lingayen Gulf.*
Activity 4	*Delineation of fry grounds in Lingayen Gulf.*
Activity 5	*Identification and assessment of marine park and artificial reef zones.*
Activity 6	*Identification and assessment of coastal tourism areas.*
Activity 7	*Identification and assessment of mangrove reforestation areas.*
Activity 8	*Identification and assessment of areas for aquaculture development.*
Activity 9	*Zonation scheme for the coastal zone of Lingayen Gulf.*

Specific GIS procedures are designed for each activity using a GIS software called Spatial Analysis System (SPANS) developed by INTERA TYDAC Technologies of Canada (Version 5.22) for PC microcomputer. Spreadsheets, text editors and database management system (DBMS) are used for processing and analysis of attribute information prior to importation into the GIS. Remotely sensed data (March 1990 Landsat Thematic Mapper) were used to update topographic and thematic maps. Rectification was done by the National Mapping and Resource Information Authority (NAMRIA) using microBrian, an application based image processing system developed by CSIRO and MPA International Pty Ltd of Australia. Ground truthing using Global Positioning System was conducted by the project staff and some information on coral reef

cover was provided by the Marine Science Institute of the University of the Philippines. Photo interpretation of aerial photographs was also conducted by NAMRIA.

To facilitate GIS analysis, each activity follows a standard procedure:

1. Specific objective - defines an objective where GIS can be applied.

2. Information and data needs - define what data are needed in doing the GIS analysis and in what format the data should be collected and processed

3. Flow of processing tasks - define the transformation of data for GIS analysis and the GIS functions to execute in order to meet the objective.

Information and data needs are of two types - map and attribute data. Maps include topographic maps, nautical charts and thematic maps (e.g., soils, slopes, physiography) as well as remote sensed data. Maps including the aerial photographs are digitized using the digitizing package of SPANS called TYDIG (Version 4.3) while remotely sensed data are in digital format imported into SPANS as raster (grid) files. Digitizing was done using a 24" x 36" CALCOMP drawing board II model 33360 with 16 button cursor. Attribute data like population data, number of fishing boats and rainfall data, etc. are encoded in spreadsheets and DBMS following SPANS format and imported as table files. Many of the attribute data collected have to undergo preprocessing to ensure data consistency, detect and correct errors, aggregation and resampling. The latter are for large datasets. Most of the attribute data are point data. Point data are processed in SPANS either as surface maps, point maps or maps with some zone of influence/interest using the buffer function. These various map layers are then overlaid according to specific objectives according to the procedure enumerated above.

Geographic Information Systems for Coastal Zone Management in Lingayen Gulf, Philippines: Relevance and Constraints[1,2]

James N. Paw[3]
Agnes G.A. Cargamento[4]

Abstract

The Lingayen Gulf area located in northwestern Philippines has been designated as an environmentally critical area due to intense multiple resource use conflicts, particularly in the fisheries sector. Recent political events have earmarked the area for industrialization. An existing integrated coastal zone management (ICZM) plan for the area does has not adequately consider development pressures, particularly industrialization. Information on development activities must be efficiently managed and updated to assist in the formulation of options and decisions. Since most of this information has spatial component, geographic information systems (GIS) would be an appropriate tool.

A pilot project on the use of GIS is being implemented to address spatial information management and to establish a zonation scheme as proposed in the ICZM plan. While considerable data are available in various government and nongovernment agencies, their capture and analysis using GIS have not been easy. Several technical, organizational and management constraints have been encountered. Nevertheless, the establishment of a GIS capability for the Lingayen Gulf area is an important step towards spatial information management and ensuring that the ICZM plan remains responsive to changing needs of the region.

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Introduction

The provinces of Pangasinan and La Union border the 2,100 km^2 Lingayen Gulf in northwestern Luzon, Philippines (Fig. 1). The Lingayen Gulf area is one of the major fishing grounds of the country. It is intensely exploited. Myriad social, economic and institutional problems have spawned due to economic and demographic pressures.

The area was the pilot site of the Association of Southeast Asian Nations (ASEAN)/United States Coastal Resources Management Project (CRMP) for its first regional attempt to promote integrated coastal area management (CAM). The output of the CRMP was a CZM plan aimed at sustainable development of coastal resources (NEDA, Region I 1992). The plan was developed through the National Economic and Development Authority (NEDA) Region I Office (NRO). The NRO will be the lead agency to oversee its implementation for the first two years.

Implementation will require substantial updating of information particularly in light of the curret industrialization thrust of the Philippine government in Region I, which was not adequately considered in the ICZM plan. Thus, information management, specifically spatial data, is needed to assist in the formulation of timely management options and policies.

Geographic information systems (GIS) have been chosen as the most appropriate tool for spatial data management. The choice was based on the experience of the Malaysian CRMP in using GIS for coastal area planning in South Johore, Malaysia (Kam 1992).

The GISCAMP Project

The GIS for CAM and Planning (GISCAMP) Project is implemented to address spatial data management as a complementary mechanism for efficient and timely utilization of information for decisionmaking. The GISCAMP is a two-year project (September 1991-January 1994) funded by International Development Research Centre of Canada (IDRC) with the International Center for Living Aquatic Resources Management (ICLARM) as the executing agency and NRO as the collaborating institution. Although the project is coordinated by NRO, ICLARM provides the overall technical and administrative supervision.

One of the recommended strategies of the CZM plan for the Lingayen Gulf is the development of a zonation scheme for both land use and water space utilization. On a broader context, the zonation scheme should consider the downstream impact of hinterland activities so that appropriate management options and policy actions can be formulated to deal with linked habitats such as forests as well as land use changes in the upland areas.

The zonation scheme proposed in the CZM plan is essentially based on ecological and resource management considerations but more focused on the coastal waters component, such as aquaculture, mangrove rehabilitation, fisheries and marine critical habitats. The terrestrial component, such as agriculture, forest land, industrial areas and tourism sites, is not well defined. Impacts of short- and long-term development activities for tourism, agriculture, industrialization and urban expansion need to be assessed and incorporated into the zonation scheme.

The GISCAMP Project is formulating a zonation scheme in response to the recommendation of the CZM plan but the context has been expanded to include development programs (largely industrialization) not adequately considered by the plan. Also, the project looks into land use/cover and water space utilization in the Lingayen Gulf area and in the watershed to quantify impacts on the resources. The project has the following objectives:

1. to evaluate coastal land use changes and marine space utilization with respect to fishing, commercial fry collection, marine parks, mangrove reforestation, aquaculture development, tourism, human settlements and artificial reef sites and their impacts using GIS;

2. to determine the sphere of influence of upland watershed activities in terms of sediment and pollutant influx into coastal areas and their impacts thereof using GIS;

3. to differentiate between natural and anthropogenic changes in the coastal zone, where possible, to pinpoint areas of intense human activities so that appropriate management guidelines can be instituted and to delineate areas for conservation;

4. to develop a zonation scheme for the Lingayen Gulf areas that is consistent with the principles of sustainable development; and

5. to establish a databank on spatial and attribute information relevant to CAM and planning at the pilot site.

Approach

Ten tasks are established to meet the above objectives. The two core tasks are GIS databank and GIS application. The latter consists of nine activities, as follows:

Activity 1 Impact of upland watershed and lowland land use activities on the coastal zone.

This activity assesses land use/cover changes and quantifies sediment loading using the Universal Soil Loss Equation.

Activity 2 Impact of human settlement development and expansion on the coastal area.

This activity documents and assesses land use changes with respect to settlement expansion in the coastal areas using GIS.

Activity 3 Delineation of fishing zones in Lingayen Gulf.
Activity 4 Delineation of fry grounds in Lingayen Gulf.

Fishing zones for conservation and management including the fry grounds will be delineated.

Activity 5 Identification and assessment of marine park and artificial reef zones.

This activity demarcates an area in Santiago Island as a marine park using GIS. Also, artificial reef sites will be identified to enhance fisheries.

Activity 6 Identification and assessment of coastal tourism areas.

This activity identifies and assesses existing and potential tourism areas under an integrated planning framework.

Activity 7 Identification and assessment of mangrove reforestation areas.

This activity identifies suitable areas for mangrove reforestation and documents mangrove conversion in the gulf area using GIS.

Activity 8 Identification and assessment of areas for aquaculture development.

Proper site selection is a very important requirement to ensure success in any aquaculture venture. With GIS, sites will be identified under a multiple resource use environment, thus, minimizing possible conflicts.

Activity 9 Zonation scheme for the coastal zone of Lingayen Gulf.

This activity integrates activities 1 to 8 and the development programs for the Lingayen Gulf in the context of a six-year (medium) term development strategy (Fig.2).

Methodology

Specific GIS procedures are designed for each activity using a GIS software called Spatial Analysis System (SPANS) developed by INTERA TYDAC Technologies of Canada (Version 5.22) for PC microcomputer. Spreadsheets, text editors and database management system (DBMS) are used for processing and analysis of attribute information before importation into the GIS while maps are manually digitized.

Remotely sensed data (March 1990 Landsat Thematic Mapper) were used to update topographic and thematic maps. Rectification was done by the National Mapping and Resource Information Authority (NAMRIA) using microBrian, an application-based image processing system developed by the Commonwealth Scientific and Industrial Research Organization (CSIRO) and MPA International Pty Ltd of Australia. Ground truthing using Global Positioning System was conducted by the project staff with assistance of the Lands Management Sector of the Department of Environment and Natural Resources (DENR) Region I. Some information on coral reef cover was provided by the Marine Science Institute of the University of the Philippines. Photointerpretation of aerial photographs was also conducted by NAMRIA.

To facilitate GIS analysis, each activity follows a procedure:

1. Specific objective - defines an objective where GIS can be applied.

2. Information and data needs - define what data are needed in the GIS analysis and in what format these should be collected and processed.

3. Flow of processing tasks - defines the transformation of data for analysis and the GIS functions to execute to meet the objective.

Relevance of GIS Technology

The GIS technology *per se* is no longer an issue when it comes to spatial information management. The issue is its use, which is largely software-dependent. It is no longer wise to invest on developing GIS since there are many commercially available packages which have proven applicability in various disciplines and activities.

With the implementation of the GISCAMP Project, the NRO is now among the few agencies outside of the national capital that has GIS. NRO is responsible for coordinating as well as technically backstopping the establishment of the Regional Physical Framework Plan (RPFP) which covers short- and long-term resource development programs for Region I. New or proposed programs and projects are expected to conform to the RPFP. Such physical planning is typically done manually in the case of topological overlays, thereby constraining and limiting spatial analysis undertaken in the plan formulation. GIS can greatly facilitate spatial analysis.

Being responsible for planning, NRO needs to revise the RPFP every few years. Revision usually coincides with the formulation of the six-year socioeconomic development program (medium-term development plan). This would require updating of spatial and nonspatial information in a format useful for decisionmaking. The CZM plan, which will be implemented by NRO, also needs periodic revision to maintain viability. The availability of GIS within NRO would not only facilitate the updating and revising tasks but also be useful in the efficient and systematic management and analysis of data. Moreover, GIS can enhance NRO's planning capability.

Constraints in Using GIS

There is no question about the importance of GIS relative to NRO's planning activities. Several constraints, however, were encountered in the piloting of the technology under the GISCAMP Project.

Technical Issues

Data being used by the project come from various agencies and institutions. The NRO has limited primary data generation program and rely largely from other agencies. Bulk of the spatial data comes from the Bureau of Soils and Water Management (BSWM) and NAMRIA. Although in most cases, data can be obtained free or at reduced cost (e.g., cost of materials), it usually takes some time to make them available, especially between NRO and other government agencies. Generally, this situation was circumvented through direct purchase by ICLARM as in the case of rainfall and remotely sensed data. Nevertheless, significant efforts, cost and time have been expended to clean and preprocess some of the collected data before being captured into the GIS because of data gaps, differences in format and scales, and lack of georeferencing. For example, many of the cadastral maps at the municipal level have been combined and redrawn to larger scales (>1:10,000) by the assessor's office (municipal/provincial) but coordinates were not included. This was also the case for maps accompanying some development plans.

GIS have very exacting requirements for data formats, definitions and integrity (Kam et al. 1992). Such requirements rendered many data previously collected by the ASEAN/US CRMP to be rejected or not directly used in GIS analysis. This situation was not due to poor data quality but rather on the method of data collection. Generally, traditional methods of data gathering are not made within a GIS framework so that spatial aspects (e.g., location and attributes) are not given sufficient attention (Kam 1993). Until such methods are changed, variability in data format, definition and scales will continue to occur.

Although there are numerous published articles on GIS applications in resource management, very few provide details on methodology. Too often, it is left to the researcher or user to figure that out in the context of the functions of the GIS software being used. Despite the enhancement of GIS functionality, GIS theories and principles are not well known or poorly disseminated. Most users generally follow procedures as explained in GIS operation manuals based on context (i.e., what output do they want) rather than understanding the principles behind each function, its limitations and how best to use or enhance it. This situation is changing, however, as GIS is becoming formalized, and educational institutions are starting to offer courses on GIS.

The development of the project's GIS database was made in conjunction with the formulation of the application studies. There is a division of labor between ICLARM and NRO but the bulk of activities is done at ICLARM. Long-term prospect (i.e., beyond the project life) was been recognized during the initiation of the database design. As a result, numerous thematic maps digitized were on provincial and regional levels at varying scales although the actual areas in some application studies were restricted to the coastal municipalities of La Union and Pangasinan. At present, the database has 340 maps (basic and derived), 46 tables and 172 vector files and 7 raster files.

A GIS consultant was hired by the project to assist in the database design and to evaluate the nine activities relative to GIS procedure. The creation of the GIS database, including preprocessing of data into GIS format, involved a large part of project timetable. This aspect was underestimated during the project proposal stage and was only realized when data collection started. Fortunately, there was enough technically skilled staff. Overall, the time and cost involved in database development were substantial. It took about 18 months to set up the database. Data collection hampered the timely encoding into GIS due to NRO staff's unfamiliarity with GIS data format and individual inertia with respect to the technology (Peuquet and Bacastow 1991). Despite the assistance and advice of the project consultant, work progress remained slow. To ensure steady progress, ICLARM and NRO needed to maintain the same database separately which is periodically updated.

Organizational Issues

Eight NRO staff are assigned to the project, mostly on part-time basis, including the project leader and the project coordinator. The project leader oversees implementation while the project coordinator takes charge of all activities at NRO including staff time allocation, data collection and day-to-day management. A technical assistant is being trained as GIS operator at NRO. There are also subject specialists who provide technical advice and process data prior to encoding into GIS. They interact closely with the GIS core staff in translating the data into GIS format. The core staff consist of the project coordinator, technical assistant, project manager and system analyst. The project manager provides the technical and administrative supervision while the system analyst operates the GIS and maintains the database. Both staff are stationed at ICLARM.

Despite the designation of key staff in the project with their corresponding duties and responsibilities, delivery of service and the required output (e.g., processed data) fall short of expectations. First, only three staff (two in ICLARM) are more or less assigned full-time (>90% of staff time). Moreover, the distance between ICLARM and NRO (about 200 km) makes it difficult, if not impractical, to directly supervise NRO project staff. Second, technical staff at NRO are limited and involvement in the project is dependent on whether they have prior commitments in their respective divisions. Third, interdivisional awareness of GIS is probably inadequate despite several in-house GIS seminars/orientations conducted by the core project staff. Hence, involvement of the various divisions in providing data and allocation of staff time for the project have been minimal and could have shortened the GIS database development. Fourth, NRO's planning orientation is still largely sectoral despite the shift to a spatial orientation brought about by its physical planning experience. The GIS application studies are multisectoral and such planning emphasis is perhaps difficult to internalize in a short period of time. Thus, active participation of the subject specialists came in rather late in the project.

NRO has very good linkage with government and nongovernment agencies within and outside Region I. When it comes to data acquisition, relatively little difficulty is encountered. Most agencies are generous in providing the data, often free. However, often the main constraint was the slow processing of requests which required constant follow-up. It took a month or so before some data were made available, thus, delaying project execution. Delays were also sometimes due to datasets getting misplaced or lost amd had to be located or reconstructed.

The cost of rectifying remotely sensed data is not cheap. Because of distortion, re-rectification of the Landsat image of the gulf is being made. Although the project intends to use the coastline segmented from remotely sensed data due to coastline change since the July 1990 earthquake (magnitude of 7.8 on the Richter scale), it is doubtful whether NAMRIA can deliver the product before the completion of all analyses. Similar situation also exists with the aerial photographs. NAMRIA is the only government agency that processes remotely sensed data and aerial photographs. Due to its numerous commitments with government and private agencies, the quality and delivery of products sometimes fall below expectation, a situation which needs to be improved.

Other problems faced by the project in the course of implementation were: late startup due to prior commitments within ICLARM and NRO; frequent power outages, that sometimes lasted six hours; transfer of NRO office; shipment of hardware and softwares (which took about three months, plus one month testing and installation); and bugs in the software (initial releases were beta version). In the long-term, sustained funding must be there for hardware maintenance, system upgrade/update and payment of software subscription fees.

Management Issues

One of the key elements in the success of any GIS project is the development of local capability such as training of indigenous technical personnel. However, most training in recent years are vendor-initiated which presupposes that one has acquired the software being marketed. Training is typically oriented towards GIS functionality available in the software with limited attention given to GIS theory and principles as well as data processing which will conform to GIS format. It is usually assumed that the trainees are aware of the integrity of the data to be used in GIS analysis.

Staff who underwent in-house training had conceptual difficulty in integrating GIS to their current activities. For example, there are standard data requirements for assessment of tourism areas which should be collected. In GIS, such data will also be used although perhaps not all can be spatially depicted. Project staff found it difficult to perceive that GIS data requirements are not at all different from those in conventional assessment procedure. This situation slowed down data collection. Indeed, individual inertia has a lot to do with the staff's sectoral orientation, disciplinary training and personal capacity to absorb and change. Also, integrated planning approach such as in ICZM, is multidisciplinary. Most staff had narrow specialization which conforms well with sectoral orientation of their current job assignments. Time and training are needed to broaden their field/performance. However, this remedy will not work if institutional structure remains sectoral.

The perception of GIS is ambivalent, especially in developing countries. There are several reasons for this. One is the lack of formal GIS program that deals with theories and principles. Another is that vendors package training programs according to the software they are marketing. Many of these GIS outputs do not provide generic methodology. Often, GIS is used as a cartographic system rather than as a spatial analytical tool. This situation is very much a reality in developing countries although it is already changing. GIS application can be severely limiting if the vendor's initiative or assistance is relied on. A consultant having a broad GIS background can help widen the sphere of GIS application; train the staff to understand the limitations of the softwares and the GIS functions. The consultant can also provide a broader perspective of data integration from disparate sources.

Lessons Learned

GIS technology is now accepted as a planning and management tool in many Philippine government agencies. The piloting of the GISCAMP Project at NRO is an addition to that growing number of agencies but it is the first to apply the technology to ICZM. Also, most GIS applications in these agencies are cartographic with limited spatial modelling. The GISCAMP Project is attempting to demonstrate spatial modelling in the context of ICZM. The project is still ongoing but will be completed by end of January 1994. In the course of its implementation, a number of lessons can be gleaned.

To ensure data integrity, a core staff should be responsible to operate the system, conduct GIS analysis and service the organization. Management support at all levels must be present although an organizational structure should be emplaced to enable the GIS unit to serve the various management levels or divisions. In the case of NRO, there are several divisions conducting sectoral activities, such as population, social services, economic development and infrastructure. A program of GIS activities should be developed to address the spatial information needs of each division while linkage with the database of each division should be established though not necessarily through networking (e.g., program interface).

Three years would normally be the length of time to fully implement a GIS project. Implementation includes training, database development and application. This can be shortened to two years or less, depending on the complexity and scale of applications, proficiency of staff and institutional acceptance. The project can begin through iterative in-house training, with emphasis on the generic functionality of GIS and assistance from a GIS consultant or expert.

Although most GIS projects, especially those with international funding support, are operational, they have limited spatial modelling capability. Much of the applications is cartographical which severely underrates the utility of GIS. To overcome this limitation, a more formal GIS training which includes theories and principles, is required. Since most GIS projects are short-term, such generic trainings are usually excluded. The training should be embedded into the long-term capability building program of the organization, through international funding support, to ensure the viability. To this end, the works of the National Center for Geographical Information and Analysis in the United States as well as some educational institutions in Europe and Canada should be used for such training (Morrison 1991). To achieve a reasonable success and integration into mainstream programs, application studies should be a subset of existing institutional activities. In the GISCAMP project, the zonation scheme and other applications are part of the CZM plan and the RPFP being implemented by NRO.

NRO has a very strong economic planning capability but the approach is largely sectoral. Most of the planning efforts are directed towards land-based activities, with minimal emphasis on the coastal and marine environment. The capability to integrate natural resource and environmental issues into planning phase is limited. Within the context of ICZM, such issues are part of the program. While NRO's sectoral orientation may be difficult to change, the planning effort can be slanted towards the multisectoral and integrated approach using GIS. GIS is an integrative tool and can utilize information from various disciplines depending on application. GIS can enhance NRO's planning capability while providing an avenue where environmental and natural resource issues can be addressed. It can also improve the technical expertise of staff with respect to integrated planning.

Conclusion

Several government agencies in the Philippines have GIS capability but most of these concentrated at the national capital. NRO is now among the few agencies outside the national capital that has GIS. Being a new technology, pilot testing was conducted through the GISCAMP Project with focus on ICZM. Several technical, organizational and management constraints were encountered. To ensure the viability of the technology and integration into mainstream activities, GIS application studies were made subsets of existing planning efforts at NRO. Sustained utilization of GIS at NRO, however, will require formal training for staff; funding allocation (i.e., for software subscription and updates, hardware maintenance, and data acquisition and processing); and interdivisional support.

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Marine Fisheries Zoning in the Lingayen Gulf, Philippines

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Abstract

The 2,100 km^2 Lingayen Gulf is one of the intensely exploited waters in the Philippines. The marine fisheries resources are overexploited with concomitant problems facing the coastal fishing communities as well as the gulf itself. The coastal area management (CAM) plan of Lingayen Gulf recommended for the establishment of a zonation scheme as a strategy for sustainable development. This study demarcated four zones for the gulf: exclusive fishing zone, general use marine zone, special management A and B. Zonation was based on Presidential Decree 704 (Philippine Fisheries Decree of 1975) including pertinent regulations thereof and Republic Act 7160. In addition, biophysical criteria were used for delineation of the two special management zones. Recommendations for refinement and implementation are discussed.

Introduction

Lingayen Gulf is one of the major fishing grounds in the Philippines. Annual marine fish landing is about 7,000 t/year. There are two subsectors in the fishing industry that operate in the gulf--municipal and commercial fisheries. The capture fisheries of the gulf is characteristically multigear for exploiting the multispecies resources. The municipal fisheries use 28 different gear types while commercial fisheries use only the trawl (Silvestre et al. 1991). About 78% of total landings come from municipal fisheries. Compared to commercial fisheries, the municipal fisheries sector employed significant larger fishermen (full and part-time). There is considerable overlap in the operational fishing areas between the two sectors resulting in serious resource use conflicts and overexploitation of the

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fisheries resources.

Major management issues affecting the marine capture fisheries sector of Lingayen Gulf are (NEDA Region I 1992, Silvestre et al. 1991, Ochavillo and Silvestre 1991, Calud et al. 1991):

1. High fishermen and boat density.

2. Low and declining catch rates.

3. High extraction rates.

4. There is growth overfishing.

5. There is recruitment and ecosystem overfishing.

6. Resource use conflicts between municipal and commercial fisheries.

7. Indiscriminate use of inappropriate or illegal fishing methods.

The Lingayen Gulf is also an important fry ground for a number of aquaculture species like milkfish (*Chanos chanos*), rabbit fish (*Siganus* spp.), groupers (*Epinephelus* spp.) and shrimps (*Penaeus* spp.). Milkfish and rabbit fish fry productions are significant with the former occurring nearly through the coasts of Region I. Unlike capture fisheries, fry collection is allowed within concession areas which are granted by the municipal government to coastal barangays, individuals or groups. In free zones, fry collection does not require municipal permit. Major management issues affecting the fry collection areas are deteriorating water quality of coastal waters, destruction of critical habitats and use of improper fishing methods.

Under the Lingayen Gulf coastal area management (CAM) plan, a zonation scheme for the gulf area is recommended as one of the strategies for sustainable development. This study proposed a zonation scheme for marine capture fisheries in the Lingayen Gulf using some of the criteria from the CAM plan.

Methodology

This study was conducted using geographic information systems (GIS). The bathymetry of the gulf was digitized as points from bathymetric charts at scales of 1:12,500 to 1:100,000 (Mercator) using a GIS software called SPANS developed by INTERA TYDAC of Canada. The point data were interpolated using the triangulated irregular network technique (Weibel and Heller 1991). Bottom substrates were also digitized from bathymetric charts and interpolated as Thiessen polygons (Kemp 1993). The polygons were collapsed into six classes based on the attribute of each points (i.e., awash, muddy, sandy, rocky, shoal and hard bottom). Coastal habitats such as coral reefs, seagrass and mangroves were segmented from the March 1990 Landsat Thematic Mapper image. The Landsat image was classified by the National Mapping and Resource Information Authority (NAMRIA) using microBrian, an image processing system development by CSIRO and MPA International, Ltd. of Australia and imported into the GIS as raster files. Ground truthing with the aid of global positioning system was conducted along several coastal areas of the Lingayen Gulf in December 1992 and January 1993. Ground truth data for Santiago Island was provided by the Marine Science Institute of the University of the Philippines.

Information on the marine capture fisheries was largely taken from the works of the College of Fisheries of the University of the Philippines in the Visayas under the ASEAN/US Coastal Resources Management Project (UPV 1990 and Silvestre et al. 1991). Operational areas of various gear types (gillnet and trawl) were taken from Ochavillo and Silvestre (1991), passive gears of Bolinao and Anda from Mines (1986) and UPMSI (1988). The mapping of the operational areas for the gillnet and trawl was based on Table 1 from the work of Calud et al. (1991). Blast fishing observations were provided by the Philippine Navy in Region I. Fry ground data were provided by the Bureau of Fisheries and Aquatic Resources (BFAR) (Signey 1992). Possible fry grounds for milkfish were generated through map overlay based on the work of Kumagai (1984).

Operational fishing areas for municipal fisheries were delineated perpendicular to the shoreline through buffering based on fisheries policies: 7 km (old policy under Presidential Decree (PD) No. 704 and Fisheries Administrative Order (FAO) No. 156) and 15 km (new policy under Republic Act (RA) No. 7160). Delineation of zones for the marine waters was based on the criteria set by the CAM plan (NEDA Region I 1992). There are four zones used in this study: general use zone, exclusive management zone, special management zone A and B. SPANS' spatial modelling was used in delineating the four zones. Fry grounds are special management zone B.

Results and Discussion

Marine capture fisheries

The surface area of the Lingayen Gulf is approximately 2,100 km^2 bordering the provinces of La Union on the east and Pangasinan on the south and southwest. Depth ranges of the gulf are less that 1 fathom nearshore,

Table 1. Operational range of gillnet and trawl in Lingayen Gulf, Philippines, based on data for the period May 1987 to April 1988 (Modified after Calud et.al. (1991).

Fishing Gear	Depth Range (m)	Distance from shoreline (km)
Bottom gillnet		
Motorized	25 - 40	7.0 - 10.0
Nonmotorized	15 - 25	2.5 - 6.0
Surface gill net		
Tuna gillnet	over 30	over 4.5
Drift gill net	over 30	over 5.0
Trawl	7 - 75	over 0.5

especially on the southern part to over 100 fathoms in the north (Fig. 1). The bottom substrates profile based on the bathymetric charts is shown is Fig. 2 including some coastal habitats. As yet, there is no new hydrographic study on the gulf that shows its actual bottom profile.

The marine capture fisheries consist of two sectors on the basis of vessel gross tonnage- municipal and commercial fisheries. Municipal fisheries sector is defined under PD 704, known as the "Fisheries Decree of 1975," as fishing operations involving fishing vessels of 3 gross ton (GT) or less including the use gear types without boats. Fishing operations using over 3 GT vessels are designated as commercial fisheries. There are approximately 28 gear types used by the municipal fisheries sector with gillnet as the most common (Fig. 3). On the other hand, trawl is the only gear type used by the commercial fisheries sector (Ochavillo et al. 1991). The total landings for the period May 1987 to April 1988 by sector as reported in Silvestre et al. (1991) is summarized in Table 2. In terms of employment, study done in 1987 by Silvestre et al (1991) showed that there were 220 fishermen directly employed in trawl operations (24 10-20 GT and 2 >20 GT vessels) whereas there were 12,500 municipal fishermen residing along the gulf with 7,000 boats. Fishing municipalities with over 100 non-motorized boats are located in southwest and western Lingayen Gulf which effectively makes them dependent on the nearshore waters for fishing (Fig.4).

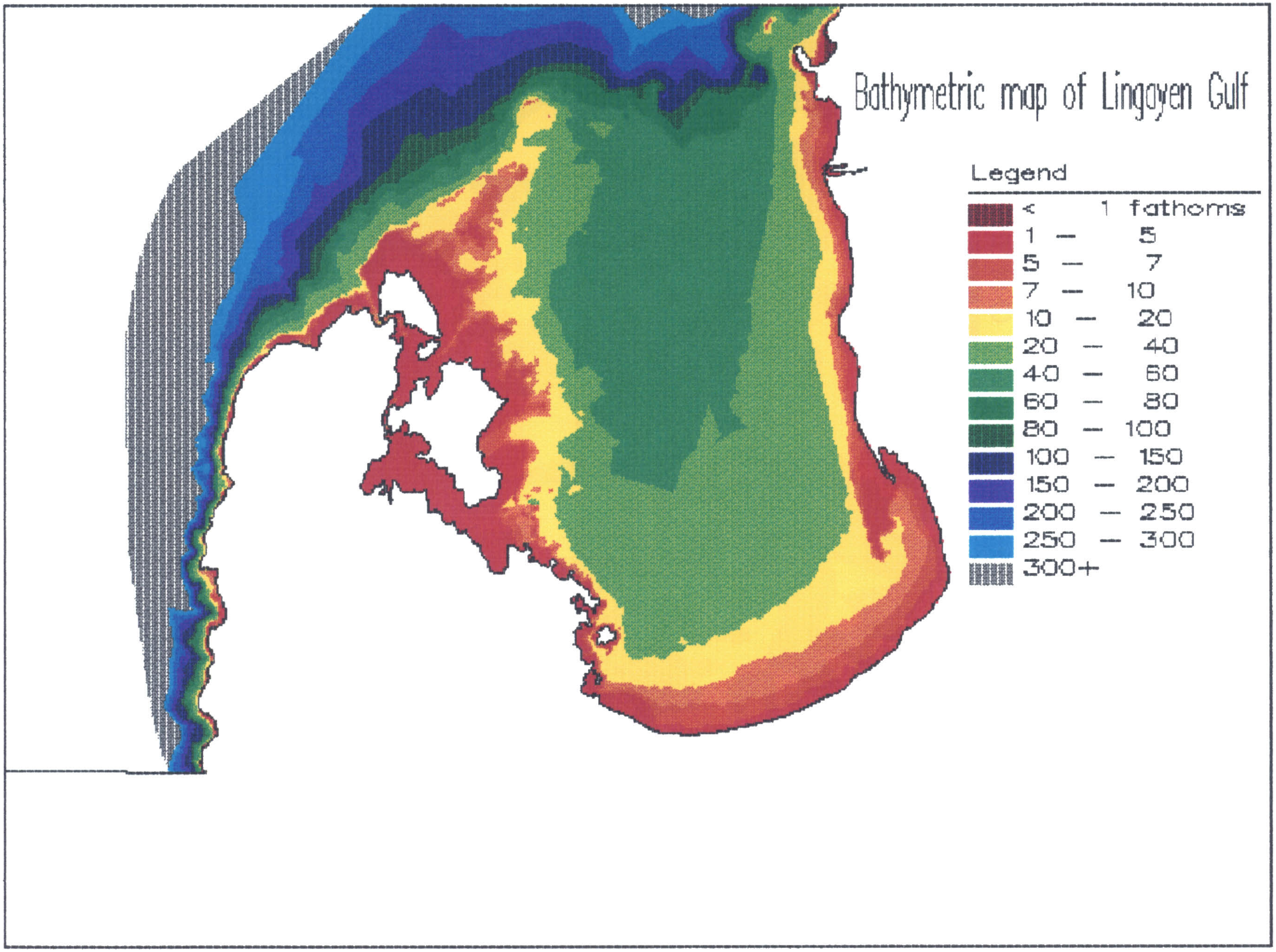
PD 704 and FAO 156 provided for a 7-km seaward demarcation from the shore as municipal fishing area and banning of trawling within. Yet, trawling significantly encroach on the municipal fisheries areas. Municipal fisheries are subject to municipal ordinances duly approved by the Department of Agriculture. Prior to the enactment of the Local Government Code of 1991 known as the RA 7160, the territorial waters of the municipal governments extend to 3 nautical miles (5.56 km) from the shore. This nearly covered most of the 7-km municipal fisheries zone. Attempts to enforce the 7-km ban on trawling remain a problem causing serious resource use conflicts between the two fisheries sectors (e.g., FAO 156). In addition, each sector contributed to the overexploitation of the fisheries resources of the gulf through the use of small mesh size nets (<3 cm); too many fishermen, especially from municipal sector; and use of inappropriate fishing methods which are compounding the overfished condition of the gulf (Silvestre et a. 1991, Mines 1986).

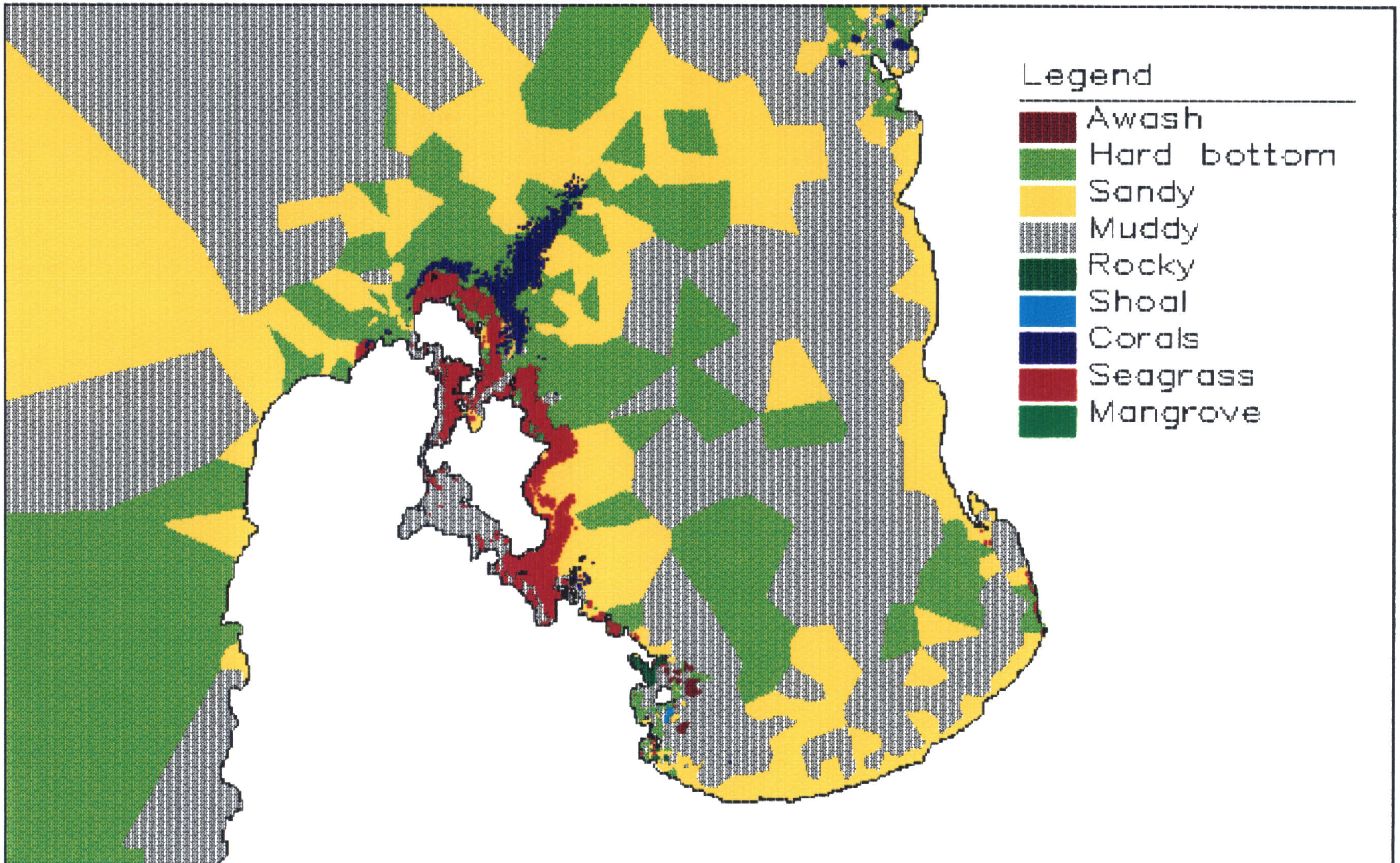
RA 7160 enlarged the municipal territorial waters from 5.56 km to 15 km. This does not imply, however, that trawling will be restricted beyond 15 km since the ban is not referring to municipal fishing boundary. As yet, there is no regulation superseding the 7-km demarcation set by PD 704 and FAO 156 for municipal fisheries. Whether it is a 7-km or 15-km demarcation, trawl operational area in both zones is significant encompassing even to a nearshore depth of 4 fathoms (Fig. 5). Using the study area of Mines (1986) (about 2,100 km^2), the GIS was used to determine the spatial overlap of trawl fishing area

Table 2. Relative contribution of the municipal and commercial sectors to annual marine landings in Lingayen Gulf for the period May 1987 to April 1988.

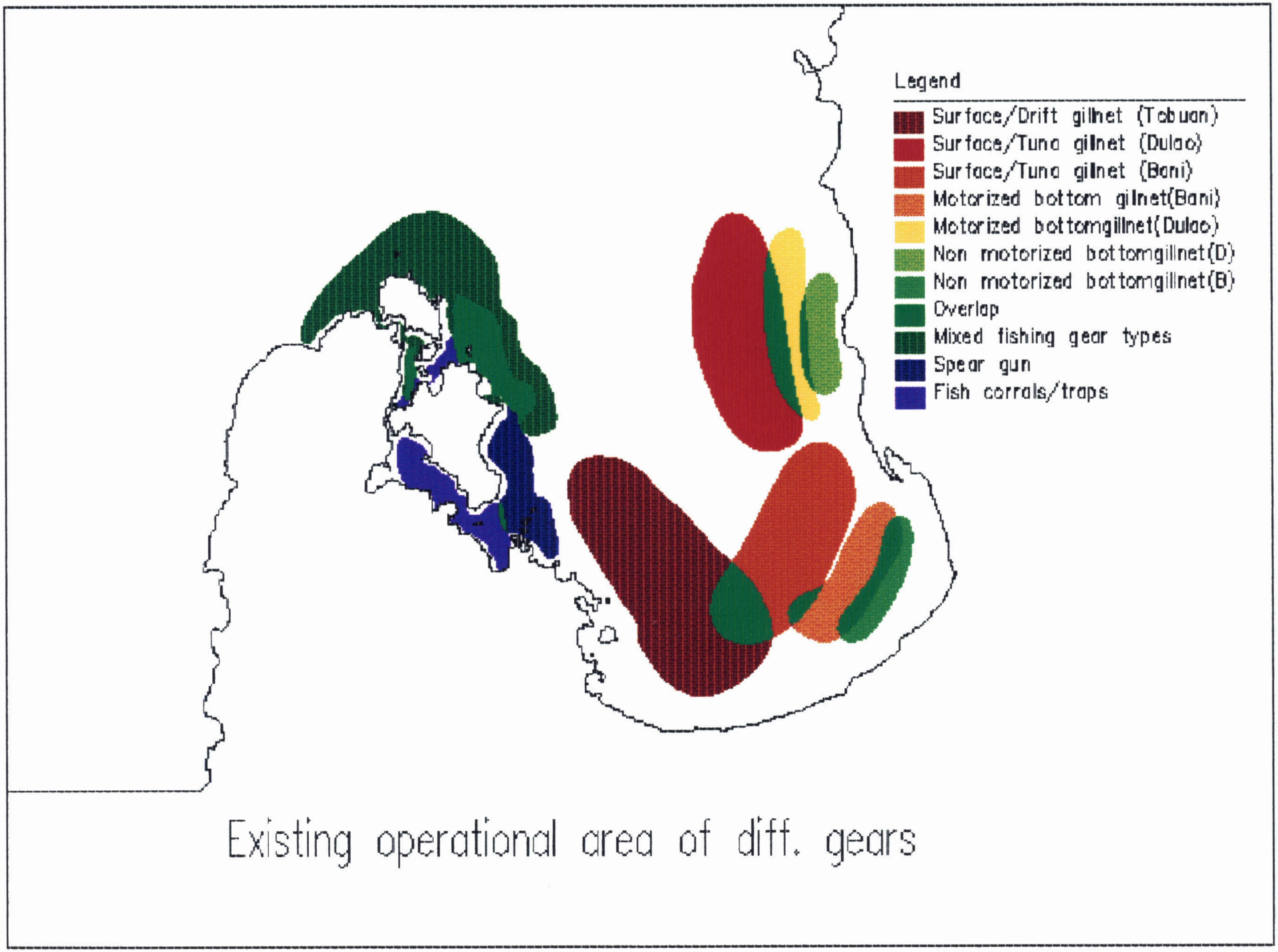
Sector/ gear type	Landings (t)	% of total landings	% of sector landings
Municipal	10,524	75.8	100.0
Gillnet	4,795	34.6	45.6
Blastfishing	1,054	7.6	10.0
Hook and line	948	6.8	9.0
Lift net	885	6.4	8.4
Shrimp trawl	826	6.0	7.8
Danish seine	446	3.2	4.2
Beam trawl	443	3.2	4.2
Others	1,127	8.0	10.8
Commercial	3,351	24.2	100.0
Large trawl	606	4.4	18.1
Medium trawl	2,745	19.8	81.9
Total	13,875	100.0	

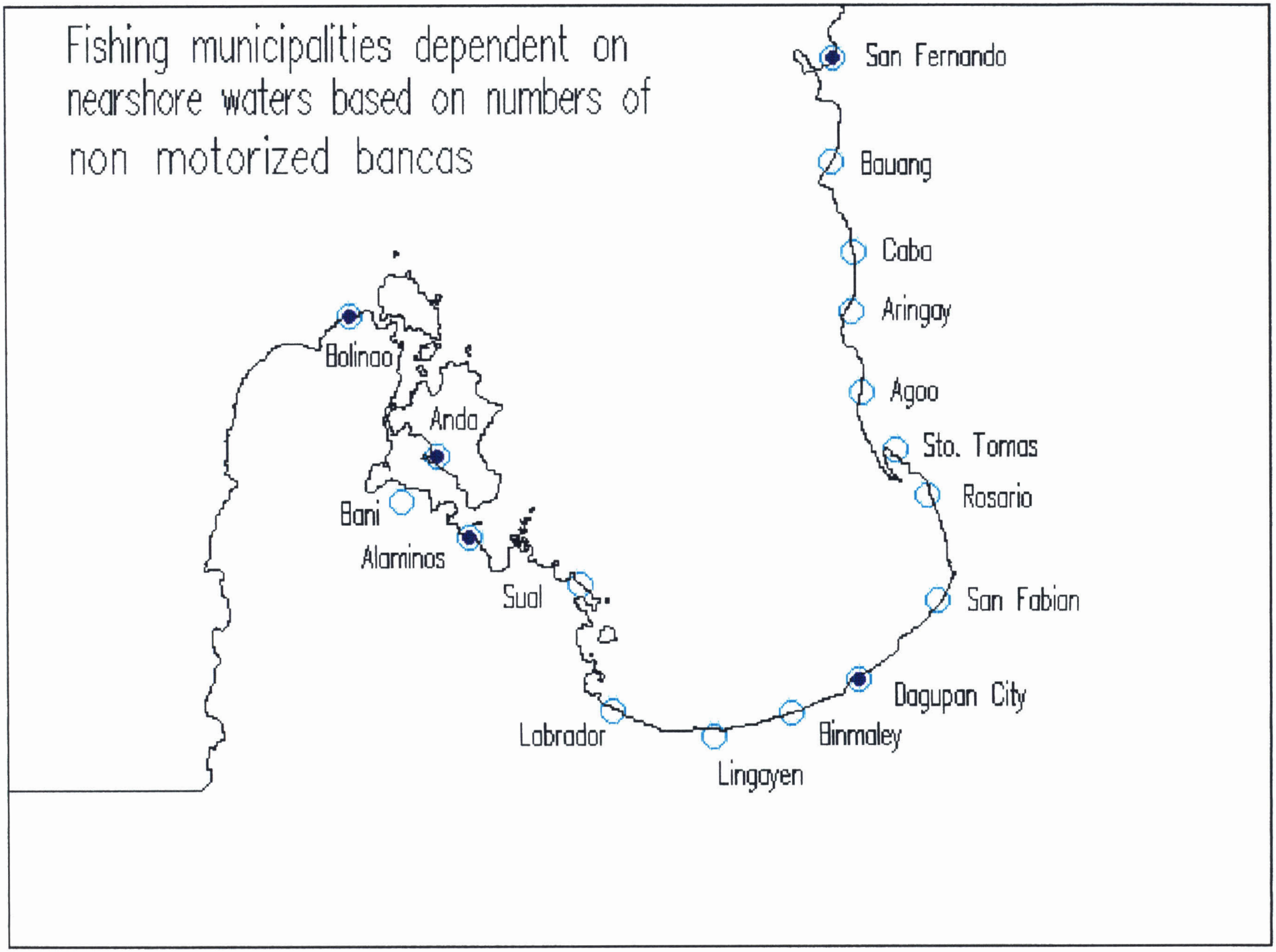
Sources: Calud et al. (1989) and Ochavillo et al. (1989).

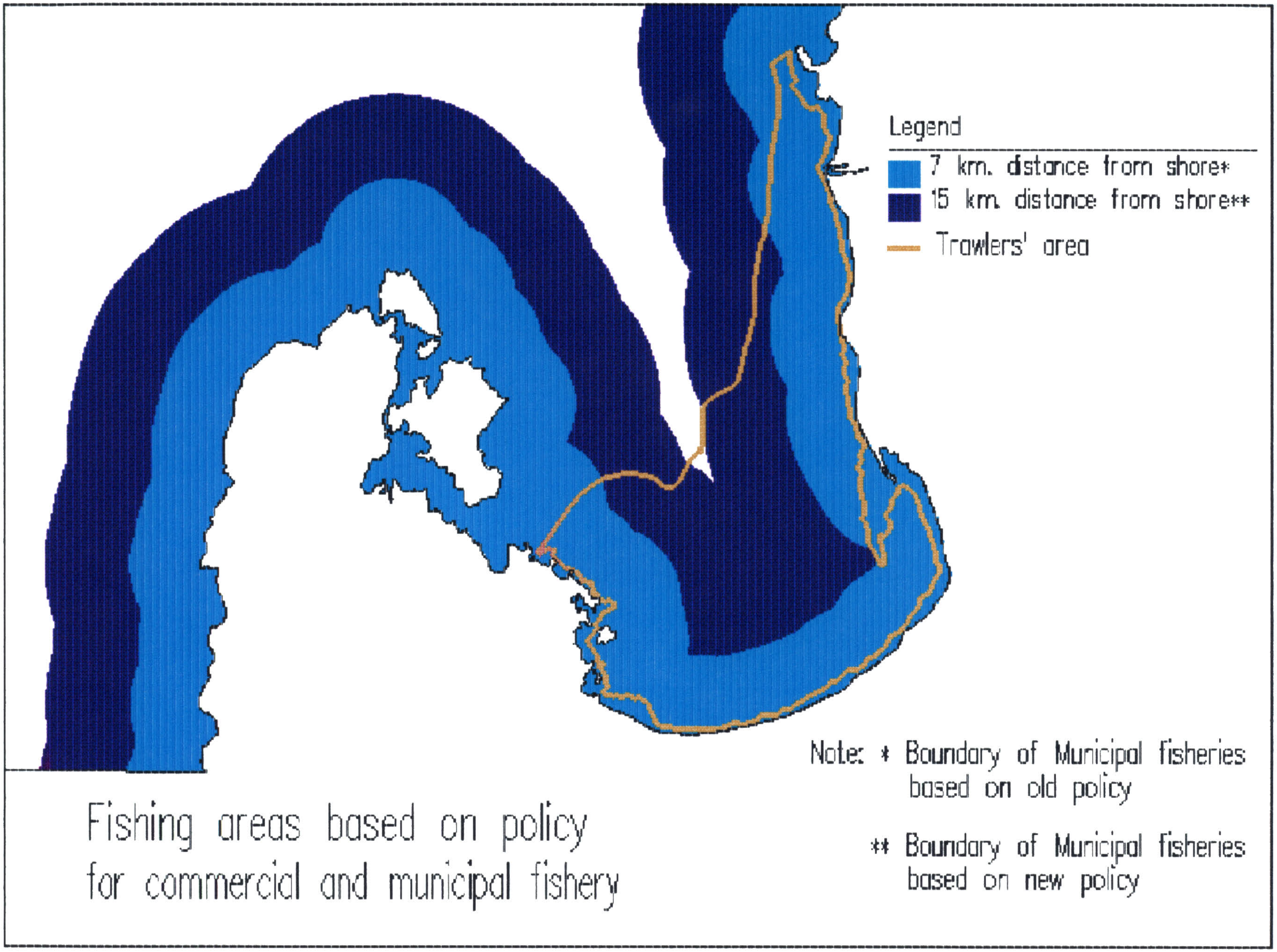

Bathymetric map of Lingayen Gulf
Legend
< 1 fathoms
1 — 5
5 — 7
7 — 10
10 — 20
20 — 40
40 — 60
60 — 80
80 — 100
100 — 150
150 — 200
200 — 250
250 — 300
300+



Bottom substrates & coastal habitats


Legend
Surface/Drift gillnet (Tabuan)
Surface/Tuna gillnet (Dulao)
Surface/Tuna gillnet (Bani)
Motorized bottom gilnet(Bani)
Motorized bottomgillnet(Dulao)
Non motorized bottomgillnet(D)
Non motorized bottomgillnet(B)
Overlap
Mixed fishing gear types
Spear gun
Fish corrals/traps
Existing operational area of diff. gears


Fishing municipalities dependent on nearshore waters based on numbers of non motorized bancas
San Fernando
Bauang
Caba
Aringay
Agoo
Sto. Tomas
Rosario
San Fabian
Dagupan City
Binmaley
Lingayen
Labrador
Sual
Alaminos
Bani
Anda
Bolinao

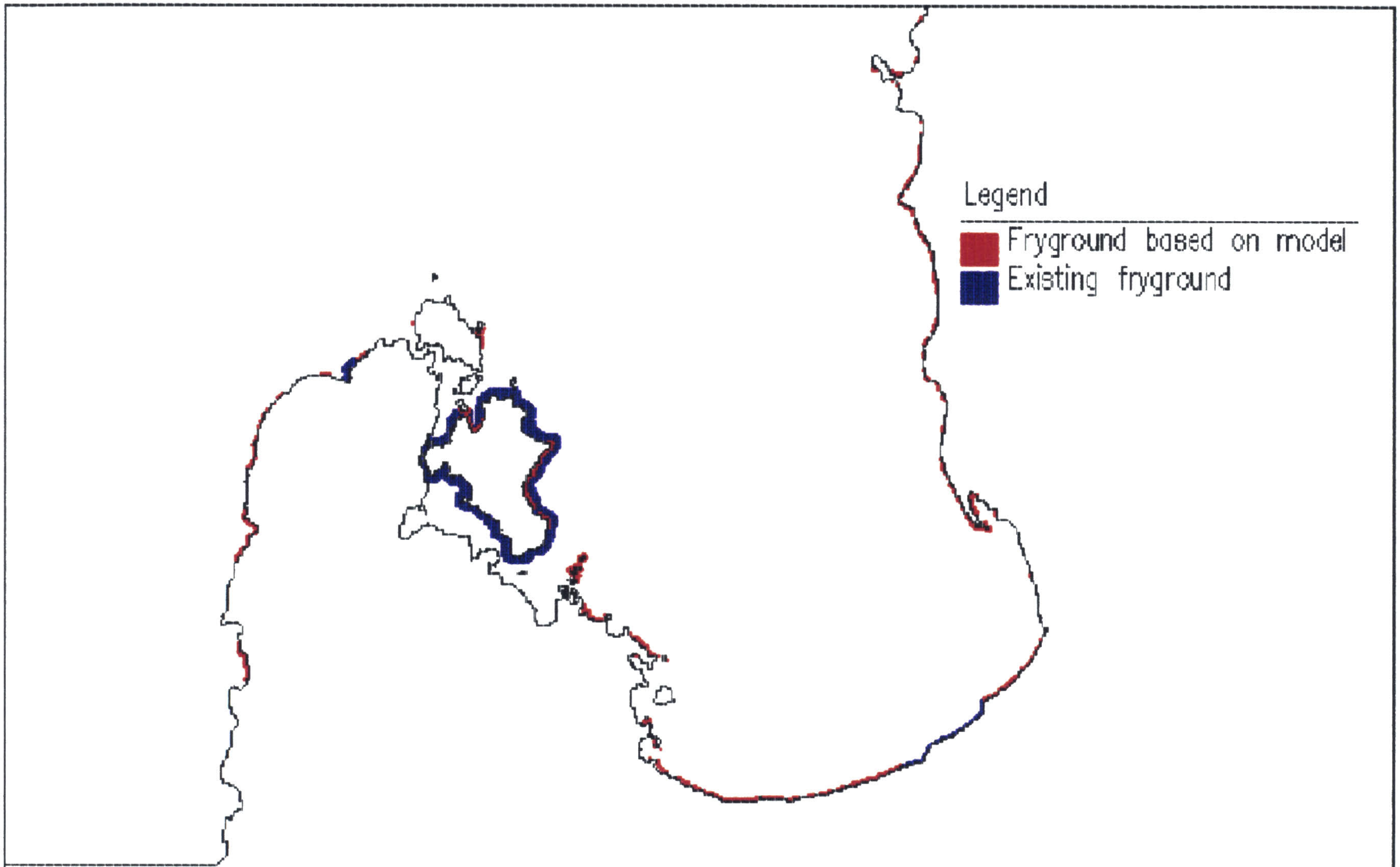


Fishing areas based on policy for commercial and municipal fishery relative to the 7- and 15-km zones. Under the 7-km policy, the effective operational area of trawl is 61.5% while under the 15-km policy, it decreased to 8.7%. For the municipal fisheries sector, the former is 38.5% and the latter is 91.3%. In reality, however, the fishing area of trawling comprised about 45.7% of the study area.

Fry grounds

The coast of Region I facing the South China Sea is a significant source of milkfish fry in northern Luzon (Smith 1981). Within the Lingayen Gulf, notable milkfish fry grounds are in the municipalities of Agoo, Sto. Tomas, Bani and Bolinao although fry occur throughout most of the coastal municipalities of Pangasinan and La Union. Table 3 shows the milkfish fry occurrence in Pangasinan and La Union based on data provided by BFAR (Signey 1992). Fry are typically gathered using fry seine or fine mesh net (*sayot*). Other species caught for aquaculture production are siganids, groupers and penaeid shrimps. Siganids are largely restricted in the Bolinao-Anda areas (northwestern Pangasinan) where there are extensive seagrass beds and coral reefs. It is an important reef-industry in Bolinao where siganids of all sizes are caught, the small ones being made into fish sauce (McManus and Meñez 1989). Only Pangasinan culture siganids in addition to the other species. The grouper fry is collected for cage culture, most of which are exported abroad while penaeid shrimps are mostly for domestic aquaculture production. Fry production of these two are not very significant compared to milkfish and siganids, particularly the shrimps which are now mass produced in hatcheries nationwide. Harvest of milkfish fry is granted by the municipal government by concession through bidding (Smith 1981). Bidders could be an individual, cooperative or a group of individuals. At present, concessions are granted to coastal barangays and fishermen's cooperatives rather than to individuals to boost income of local communities.

The fry grounds of Lingayen Gulf (Fig. 6) are increasing being threatened by pollution (e.g., industrial and domestic including sedimentation), destruction of critical habitats (i.e., coral reefs, seagrass and mangroves) and overexploitation, both of the fry and mature stocks. Data on fry grounds are limited, particularly the spatial component. Based on Signey (1992), milkfish fry occur throughout most of the gulf coast but the stock level which vary according to season, is not known. Using some of the fry ground indicators identified by Kumagai (1984), namely, sandy bottom, distance of 250 m from the shore (seaward limit of fry occurrence in Hamtik, Antique, Central Philippines) and depth up to 20 m, several sites along the coast have been generated through non-weighted map overlay (Fig. 6). Some of these areas matched the data of Signey (1992). Ground assessment of the sites, however, was not conducted.



Milkfish fryground in Lingayen Gulf

Table 3 Survey data on Fry grounds in Lingayen Gulf (Signey 1992).

Province Town/City	With Fry Grnd	If "Yes" is the Area Under Concession 1989	Concession 1990	Free Zone 1989	Free Zone 1990	Dominant Species Collected	Other Species Collected	Estimated Prod'n on Bangus Fry 1989	Estimated Prod'n on Bangus Fry 1990	Estimated Prodn. of other species 1989	Estimated Prodn. of other species 1990	With Fry Coop	If "Yes" write down Name and Address	Barangay Considered fry gathering Area
Pangasinan														
Agno	Y	x	x			bangus						N		Macaboboni Naleng Boroy Marucan Tapa Gayusan
Alaminos	N											Y	PROVADIC Pangasinan Rural Union Dev't. Action Venture Integrated Coop Pogo Coop.	
Asingan	Y	x		x	x	lapu-lapu siganid	seabass bangus							All barangays

Table 3 Survey data on Fry grounds in Lingayen Gulf (Signey 1992).

Province Town/City	With Fry Grnd	If "Yes" is the Area Under Concession 1989	Concession 1990	Free Zone 1989	Free Zone 1990	Dominant Species Collected	Other Species Collected	Estimated Prod'n on Bangus Fry 1989	Estimated Prod'n on Bangus Fry 1990	Estimated Prodn. of other species 1989	Estimated Prodn. of other species 1990	With Fry Coop	If "Yes" write down Name and Address	Barangay Considered fry gathering Area
Bani	Y			x	x	bangus		.005M	.005M			N		Ducap Sur
Bolinao	Y	x	x			bangus		.007M	.085M			N		Arnedo Balingasay Ilob Malino Patar Victory
Burgos	Y			x		bangus fry malaga pusit	malikan					N		Ilin-ilin
Bugallon	N													
Dagupan	Y			x	x	sugpo lapu-lapu	bangus					Y	Unspecified	Pugaro Bonuan Gueset Binloc

Table 3 Survey data on Fry grounds in Lingayen Gulf (Signey 1992).

Province Town/City	With Fry Grnd	If "Yes" is the Area Under Concession 1989	Concession 1990	Free Zone 1989	Free Zone 1990	Dominant Species Collected	Other Species Collected	Estimated Prod'n on Bangus Fry 1989	Bangus Fry 1990	Estimated Prodn. of other species 1989	other species 1990	With Fry Coop	If "Yes" write down Name and Address	Barangay Considered fry gathering Area
Dasol '(fry dealer conces-sionaire himself)	Y	x	x	x	x	bangus						N		Macalang Egua Patas Hermosa Gualbalan Malacapas Uli/Osmena
Binmaley	N													
Infanta	Y	1,2,3 & 5	1,2,3 & 5	Balaki Is.		bangus	prawn malaga	2.5M	2.0M	.15M	.20M	Y		Nayom Poblacion Cato Batang Bayambang Balaki Is.
La Union Agno	Y			x		bangus	prawn shrimp	.10M				Y	There's a fisherman's	San Miguel Sur San Miguel Nort

Table 3 Survey data on Fry grounds in Lingayen Gulf (Signey 1992).

Province Town/City	With Fry Grnd	If "Yes" is the Area Under Concession		Free Zone		Dominant Species Collected	Other Species Collected	Estimated Prod'n on Bangus Fry		Estimated Prodn. of other species		With Fry Coop	If "Yes" write down Name and Address	Barangay Considered fry gathering Area
		1989	1990	1989	1990			1989	1990	1989	1990			
Bacnotan	Y	x			x	bangus						N		Baroro Poblacion Canocalao Maragayap Pandan Cabarsican Quirino Galongen
Balaoan	Y	x	x			bangus								Darigayos Paraoir Norte
Sto. Tomas (with fry dealers)	Y			x	x	bangus	sugpo	.03M	.02M			Y	Sto. Tomas	Cabaroan Narvacan Baybay Casantaan
San Juan	Y	x	x			bangus						N		Taboc

Table 3 Survey data on Fry grounds in Lingayen Gulf (Signey 1992).

Province Town/City	With Fry Grnd	If "Yes" is the Area Under Concession 1989	Concession 1990	Free Zone 1989	Free Zone 1990	Dominant Species Collected	Other Species Collected	Estimated Prod'n on Bangus Fry 1989	Bangus Fry 1990	Estimated Prodn. of other species 1989	other species 1990	With Fry Coop	If "Yes" write down Name and Address	Barangay Considered fry gathering Area
							apahap seabass						cooperative w/c deals only in catching marketable fish (specially shark)	San Isidro San Nicolas Balaurte San Julian West San Julian N. Sta. Rita Sur Sta. Rita West Sta. Rita Nalinac
Agoo												Y	San Manuel Norte Fisherman's Multi-purpose Coop., San Manuel, Agno	
Aringay	Y			x	x	bangus						Y	Unspecified	Samara Alaska Dulao

Table 3 Survey data on Fry grounds in Lingayen Gulf (Signey 1992).

Province Town/City	With Fry Grnd	If "Yes" is the Area Under Concession 1989	Concession 1990	Free Zone 1989	Free Zone 1990	Dominant Species Collected	Other Species Collected	Estimated Prod'n on Bangus Fry 1989	Bangus Fry 1990	Estimated Prodn. of other species 1989	other species 1990	With Fry Coop	If "Yes" write down Name and Address	Barangay Considered fry gathering Area
Bangar	Y		x	x		bangus	prawn							Paratong Norte Mindoro
Bauang	Y	x	x	x		bangus	sugpo lapu-lapu					N		Paringao Pagdalayan Uruguay Bagbag Puelo
Caba	Y	x			x	bangus						N		Santiago Sur Santiago Norte San Carlos Wenceslao
Luna	Y	x	x			bangus		1.2M				Y	Darigayos Fisherman's Marketing Cooperative	Darigayos Carisquis Nalvosup Barrientos
San Fernando	Y		under contract			bangus						N		Pagdaraoan

Table 3 Survey data on Fry grounds in Lingayen Gulf (Signey 1992).

Province Town/City	With Fry Grnd	If "Yes" is the Area Under Concession 1989	Concession 1990	Free Zone 1989	Free Zone 1990	Dominant Species Collected	Other Species Collected	Estimated Prod'n on Bangus Fry 1989	Estimated Prod'n on Bangus Fry 1990	Estimated Prodn. of other species 1989	Estimated Prodn. of other species 1990	With Fry Coop	If "Yes" write down Name and Address	Barangay Considered fry gathering Area
			by open bidding											Ilocanos Norte
														Ilocanos Sur
														Catbangan
														Pagdalagan
														Poro Point

Marine water zoning

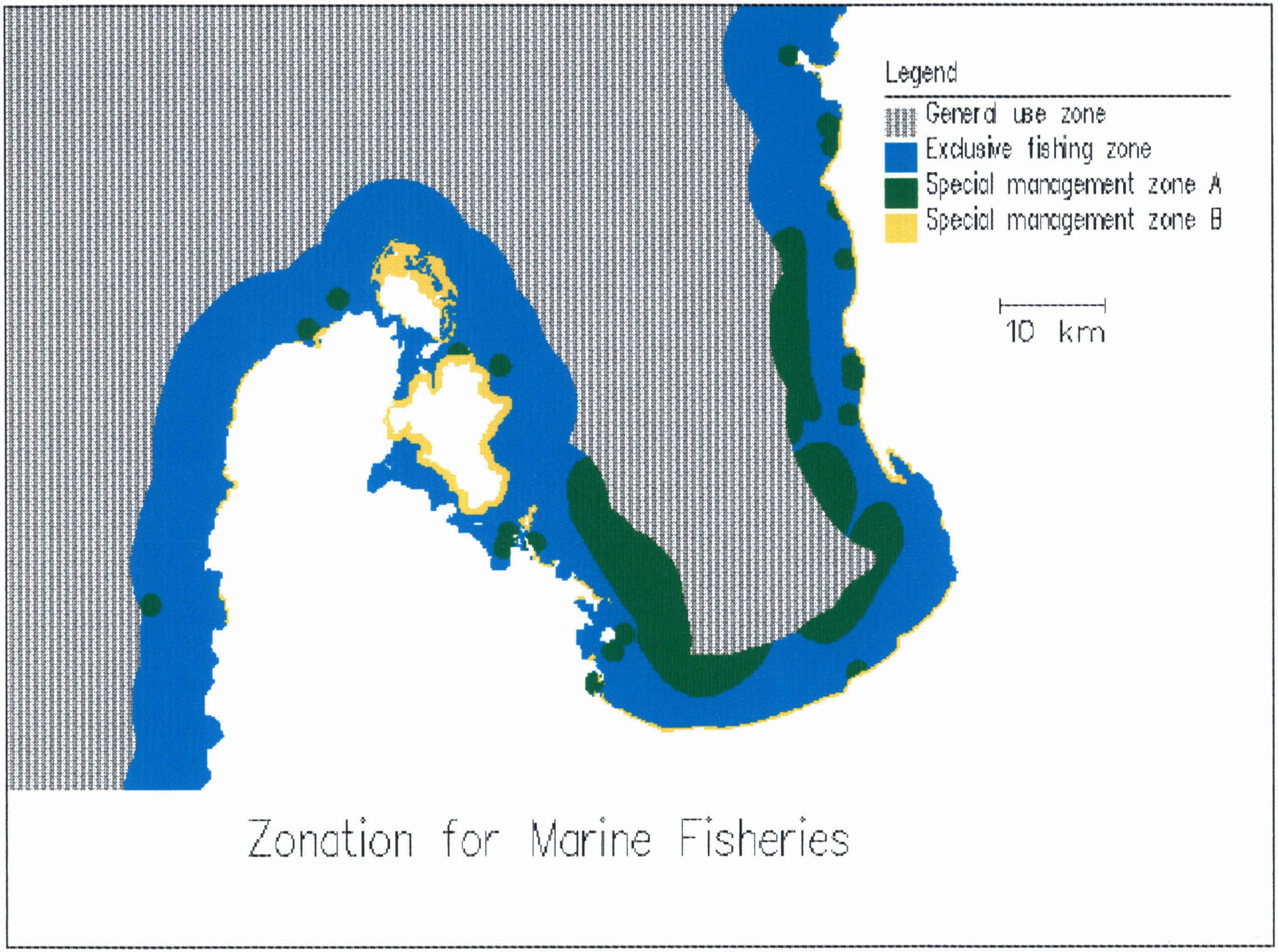
Given the inter- and intra-sectoral problems affecting the marine capture fisheries of Lingayen Gulf, the CAM plan recommended for a coastal zonation scheme (NEDA Region I 1992). Zonation essentially delineates areas where certain uses should be encouraged while banning or regulating incompatible or destructive activities, based on some environmental and other criteria. The CAM plan recommended two zones for the marine waters but under this study, additional two zones are included (Fig. 7). These are:

1. exclusive fishing zone;
2. general use marine zone;
3. special management zone A; and
4. special management zone B.

Exclusive Fishing Zone

PD 704 does not provide any distinction between passive and active gear types in terms of their operational areas within the municipal fishing zone (i.e., within the 7-km zone). In passive gear, movement of sweeping the waters or motorized pursuit are absent whereas active gear effect catching of fish by lifting, towing or driving fish into an impoundment. Generally, most passive gear types are employed nearshore such as hook, fish corrals and fish pots. On the other hand, active gear types like gillnets and Danish seines are operated to a depth of 40 m or more using motorized boats. Essentially, fishermen using passive gear types are economically marginal than those using active gear types. The average income of fishermen with motorized boat (banca) for example, was 1,118 pesos/month while those with non-motorized banca was about 431 pesos/month (LG-CAMP 1988).

As a strategy towards reducing competition within the sector, it is necessary to separate the operational areas of passive and active gear types. Such strategy would give the more disadvantaged fishing communities access to the resource. The separation into active and passive gear is a proposed amendment to PD 704. In addition, the CAM plan recommends the separate operational areas for the each gear category. Since the municipal boundary has been extended to 15 km from the shore, this study recommends that the 7-km zone under PD 704 be declared as Exclusive Fishing Zone (EFZ) for passive gear types whereas fishing operations using active gear types should be permitted only beyond the 7-km demarcation. Fishing operations within the EFZ should be


Legend
General use zone
Exclusive fishing zone
Special management zone A
Special management zone B
10 km
Zonation for Marine Fisheries

consistent with municipal ordinances and PD 704 and amendments thereof as well as existing environmental laws. Critical habitats should be protected and conserved.

General Use Marine Zone

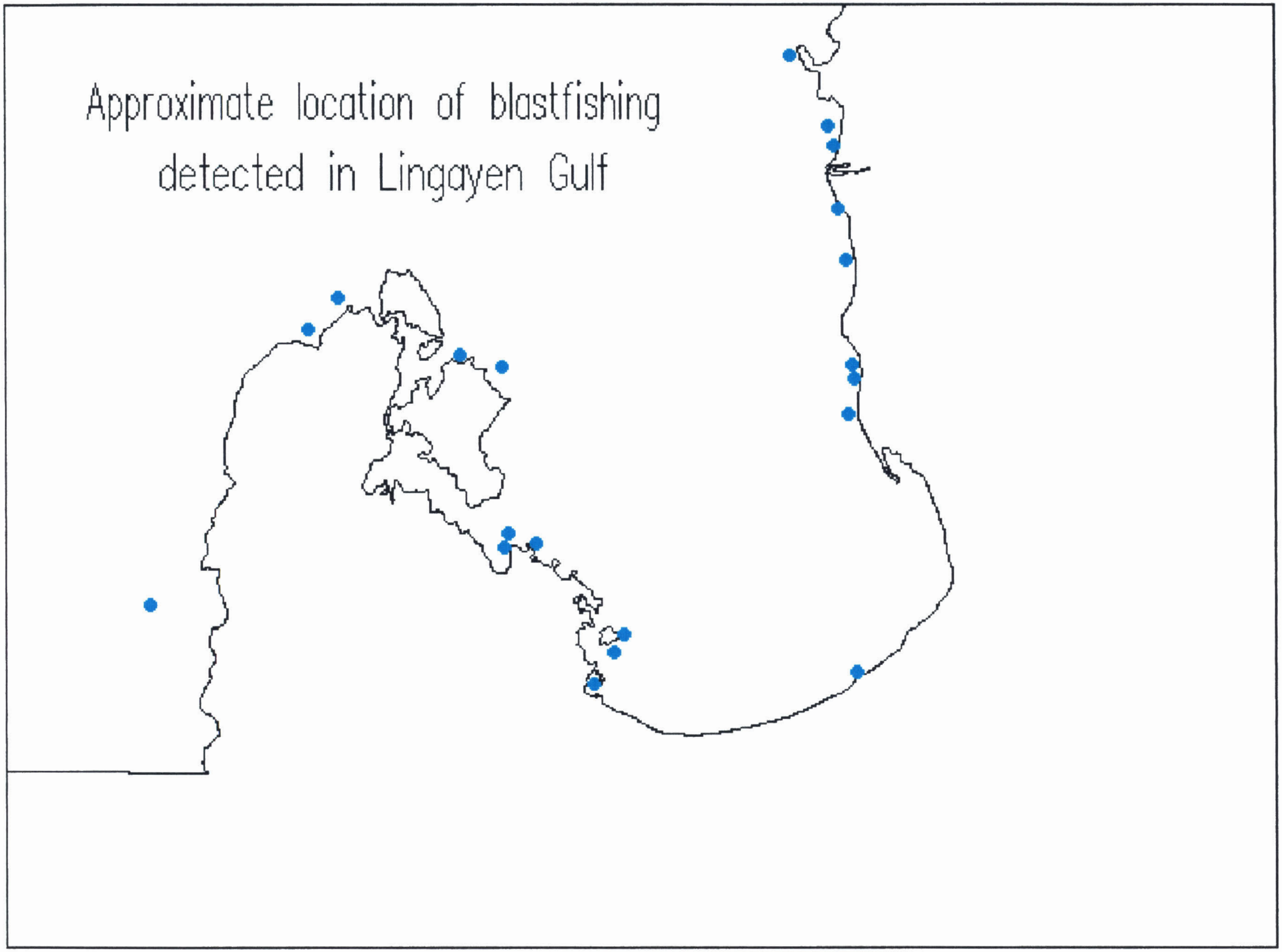
The waters beyond the 7-km zone or the EFZ will be designated as General Use Marine Zone (GUMZ). Fishing operations within the GUMZ would be for active gear types. Since RA 7160 does not provide for the exclusion of trawling within the 15-km municipal boundary, trawling should be allowed to operate within the GUMZ provided operations should be consistent with PD 704 and Letter of Instruction (LOI) 1328 as well as FAO 156. In view of the expansive operational area of trawling, monitoring of its operation should be strictly enforced. In addition, interaction between municipal fishermen using active gear with trawlers should be monitored to minimize conflict under such time as new amendments to the RA 7160 are provided for regarding the operations of trawls. Fishing operation within the GUMZ should be consistent with existing municipal ordinances, PD 704 and amendments thereof including existing environmental laws.

Special Management Zone A

Blast fishing is rampant in the gulf (Galvez et al. 1989, Silvestre et al. 1991). Despite its illegal nature, it is tolerated by the fishing communities and at sometimes by the authorities. Legal sanctions on blast fishers have not been effective due to legal and institutional constraints (Galvez 1989). Areas identified by the Philippine Navy where blast fishing have been observed is shown in Fig. 8. These sites including the operational areas of active gear that overlap with the 7-km zone are considered as Special Management Zone A (SMZA). This zone is demarcated solely to ensure that the designated areas, particularly where blast fishing have been observed should be under a special monitoring scheme to regulate illegal activities as well as potential resource use conflict. With regards to the overlap areas of active and passive gear, regulation can come from issuance of permit as well as monitoring of fishing areas. Environmental laws and pertinent fishing regulations and ordinances should apply for SMZA.

Special Management Zone B

Special Management Zone B (SMZB) refers to fry grounds. Regulations pertaining to conservation of habitats, catching of fry and broodstock (e.g., mature milkfish or *sabalo*), environmental protection (e.g., pollution, cyanide and blast fishing) should be strictly enforced within this zone. Subsistence coastal


Approximate location of blastfishing
detected in Lingayen Gulf

communities should be given priority in the harvest of fry. Management of the fry grounds should be part of the common property management (CPM) scheme for Lingayen Gulf and entrusted to coastal communities.

Implementation and recommendations

Implementation will require further refinement of the marine zonation scheme proposed by this study at map scale larger than 1:50,000 (Universal Transverse Mercator). Except for the EFZ and GUMZ, the SMZA has an arbitrary, if not, imaginary boundary. It is recommended by this study that SMZA should be a zone subjected to a special monitoring scheme *ipso facto* rather than as a clearly demarcated zone such as the EFZ. Monitoring could be based on the issuance of fishing permit for active gear (i.e., to determine fishing area and by whom) as well as based on observations of fishing areas using illegal fishing methods (e.g., blasting).

The 7-km boundary for EFZ should be one of the proposed amendments to PD 704 in addition to the separation of active and passive gear types. Likewise, active gear and trawls should be restricted to the GUMZ. In the case of trawls, the establishment of a CPM regime would eventually remove them from the municipal waters. Currently, however, trawling is still fishing within the two zones. Hence, this study further recommends the strict enforcement of LOI 1368 and FAO 156 to regulate trawling.

With the extension of municipal water boundary to 15-km under RA 7160, restriction of trawling to beyond 15 km could be realized through enactment of intermunicipal ordinance. This would effectively provide about 42% of the gulf area (based on Mines 1986 study area) as fishing zone for active gear and the exclusion of trawling even in the absence of a CPM. The zonation scheme proposed in this study should be subjected to consultation with the Regional Land Use Committee of Region I and other relevant authorities. Refinement for implementation should be consistent with the goal and objectives of the CAM plan.

Conclusion

The CAM plan recommended the zoning of the Lingayen Gulf as one of the strategies of sustainable development. This study articulates that scheme based on existing legal instruments such as PD 704 and RA 7160. This study recommends four zones: exclusive fishing zone, general use marine zone, special management zone A and B. The zonation scheme will not be effective to address current fisheries problems unless enforcement with the necessary logistic, financial and manpower supports are available. Although the zonation scheme can regulate resource use conflicts and to some extend the conservation of resources, the high dependency of coastal communities on the fisheries resources of the gulf and high population of fisherfolk could be counterproductive to such an effort. It would be necessary to reduce the number of fisherfolk through provision of alternative livelihood projects since the fisheries resources are already overexploited.

Acknowledgement

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Addendum

The enlargement of the municipal territorial waters to 15 km under RA 7160 effectively bans commercial fishing within much of the gulf. Further, such ban can be regulated through the issuance of fishing permit. Under PD 704, municipal government is empowered to issue such permit to municipal fishers only. Therefore, commercial fishers cannot fish in municipal waters, in this case, within 15 km from the shore. Moreover, permit for commercial fishing is issued by the regional office of the Department of Agriculture. As such, it can regulate trawling operations to ensure non-encroachment into municipal waters. In reality, however, commercial fishing still operates within municipal waters. The CAM plan recommends the eventual phaseout of trawling in Lingayen Gulf. Therefore, the proposed marine zonation scheme tentatively places commercial fishing under the General Use Marine Zone together with municipal mobile gear users in the meantime that it is still active in the gulf.

Site Identification for Artificial Reefs and Establishment of a Marine Reserve in Lingayen Gulf, Philippines

Fe Domingo[1], James N. Paw[2], Zoraida N. Alojado[2]

Abstract

Lingayen Gulf is a major fishing ground in the Philippines but beset with numerous management problems such as overexploiation of stocks, conflict between commercial and municipal fishers as well as critical habitat degradation. The establishment of artificial reefs (ARs) and marine reserve is one strategy of enhancing fisheries resources. A key element in the success of an ARs project is proper site selection. This study assessed the Lingayen Gulf for suitable areas to site ARs using geographic information systems. About 6% of the gulf area are possible ARs sites but would require more detailed data for the purpose of implementation. Implementation, however, must also consider socioeconomic, institutional and legal issues as well as assessing past ARs effort in order to ensure success in any future endeavors.

Extensive coral reefs, some with relatively fair live coral cover are found in Western Lingayen Gulf, particularly in the municipalities of Bolinao and Anda. A marine reserve has been proposed for an area in Santiago Island, Bolinao. Detailed mapping of the area is necessary in order to demarcate actual reserve boundaries. The establishment of the reserve is aimed at enhancing the fisheries resources in the reef and nearby waters, improve the socioeconomic conditions of the fishers, attract nature-oriented tourists and for scientific and educational purpose. Broad management issues regarding implementation are similar to ARs but a strong element of public awaress is necessary in order that communities will be able to assist in establishing such a reserve.

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Introduction

The Lingayen Gulf is endowed with extensive areas of coral reels and seagrass beds, particularly in Western Pangasinan and portions of Bacnotan and San Fernando in La Union. Most of the reefs, however, are in poor to fair conditions in terms of live coral cover. In Western Pangasinan, good reefs are located in Santiago and Cabarruyan Islands (McManus and Meñez 1989). Major management issues affecting coral reefs are blast fishing, overexploitation of stocks, coral harvesting and use of poison to catch aquarium fishes (Galvez 1989, Meñez et al. 1991, McManus et al. 1992).

Lingayen Gulf is a major fishing ground in the Philippines and within Region I. The fisheries sector has been beset with myriad problems ranging from overexploitation of stocks to intense competition among municipal and commercial fishermen (Silvestre et al. 1991). One of the strategies towards enhancing fisheries stocks is the use of artificial reefs which can serve as habitats and shelter for marine organisms, particularly in areas where natural reefs have been degraded (Miclat and Miclat 1989). Artificial reefs (ARs) are not new in Lingayen Gulf. Since 1981, a number of ARs have been emplaced (Miclat and Miclat 1989, Kitamado 1984). Inadequate management and poor site selection process have contributed to the failures of many ARs projects in the gulf including low appreciate on the ecological role of ARs among municipal fisherfolk. This study assesses the gulf for possible areas to site ARs.

Another strategy of enhancing fisheries resources in Lingayen Gulf, especially in Western Pangasinan is the establishment of a marine reserve in areas with relative good live coral cover. Marine reserve would be set aside as nonfishing area which will enable fishes, invertebrates and seagrasses to attain natural population levels with very low disturbance from human activities. A marine reserve has already been identified in Santiago Island, Bolinao, Pangasinan (McManus et al. 1992). This study also demarcates the boundaries of the reserve for the purpose of inclusion into a zonation scheme for the Lingayen Gulf.

Methodology

This study consists of two parts using geographic information systems (GIS): site selection for artificial reefs (ARs) and mapping of a marine reserve in Santiago Island. The GIS software used is called SPANS developed by INTERA TYDAC of Canada.

In the site selection of ARs, criteria used were taken from Miclat and Miclat (1989) and White et al. (1990):

a. ARs must be sited >1.0 km away from natural reefs.
b. It should be sited near an alternative food sources (e.g., seagrass beds).
c. The sea bottom should be barren with flat or gently sloping profile.
d. The site must have relatively good visibility (water transparency).
e. Depth range should be 15 to 25 m and protected from wave actions and strong current (<0.5 m/sec).
f. Accessibility to local fishermen.
g. It should have sandy substrate or firm bottom.
h. Low siltation or away from rivermouth.
i. Away from pollution and navigational channels.

The bottom substrates profile and bathymetry of Lingayen Gulf were digitized from bathymetric charts (1:12,500 to 1:100,00 scales) as points. For bottom substrates, there were six categories (awash, sandy, muddy, rocky, shoal and hard bottom) and a map was generated by interpolation of the point data as Thiessen polygons (Kemp 1993). These polygons were subsequently collapsed into the six categories mentioned above. Point data on depths were interpolated using the triangulated irregular network technique and generated a bathymetry map (Weibel and Heller 1991). The bottom substrates and bathymetry maps were combined and a map was generated with two categories: depth between 15 m and 25 m with sandy/hard bottom (I) and with muddy bottom (II). Coral reefs were segmented from the 1990 Landsat Thematic Mapper image rectified by the National Mapping and Resource Information Authority (NAMRIA) as well as sediment plumes. Buffers were created around coral reefs (1 km) and river mouth (6 km). A 3-km buffer was constructed along the coastline. This map represents the optimum seaward limit in which the eye can see unaided. This would enable the coastal communities to patrol ARs from the shore instead of deploying boats to guard the site. These map layers were overlaid and selectively determined suitable sites for ARs using SPANS modelling. The result was compared to the works of Kitamado (1984) and existing ARs sites.

For the marine reserve, mapping was based on McManus et al. 1992 and UPMSI (1988). The site of a proposed marine reserve is in Santiago Island, Bolinao, Western Pangasinan. Live coral cover, particularly in a site known as the Malilnap Channel is relatively fair (>45%). Landward boundary was based on land use (fishponds) instead of the physiographic characteristics (beach and tidal flats). Base map of Santiago Island was digitized from topographic map (1:25,000) published by the Bureau of Coasts and Geodetic Survey. Marine features were taken from the 1989 SPOT MS and 1990 Landsat TM images rectified by the National Mapping and Resource Information Authority (NAMRIA). Land use map was taken from the Bureau of Soils and Water Management.

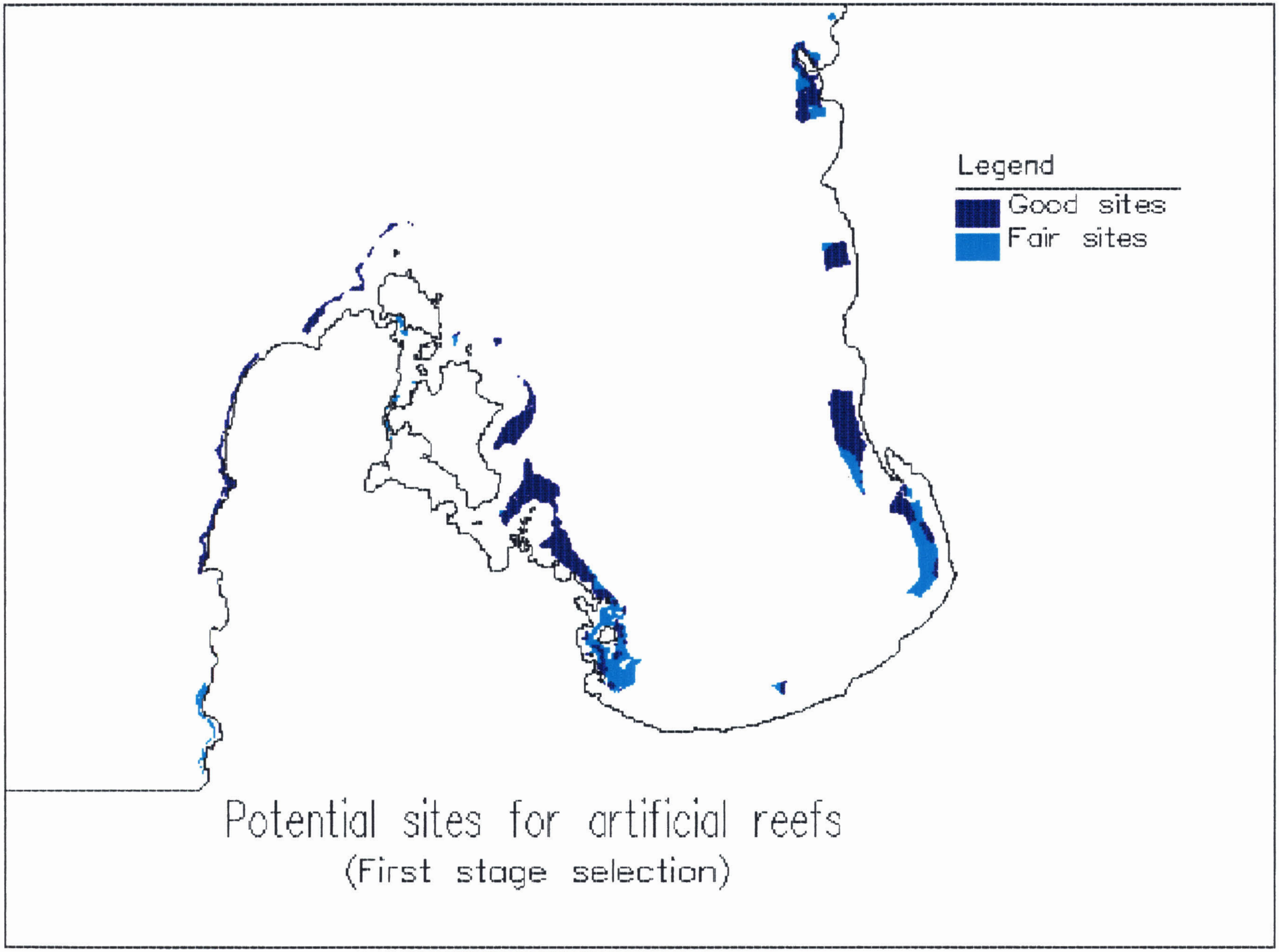
Results and Discussion

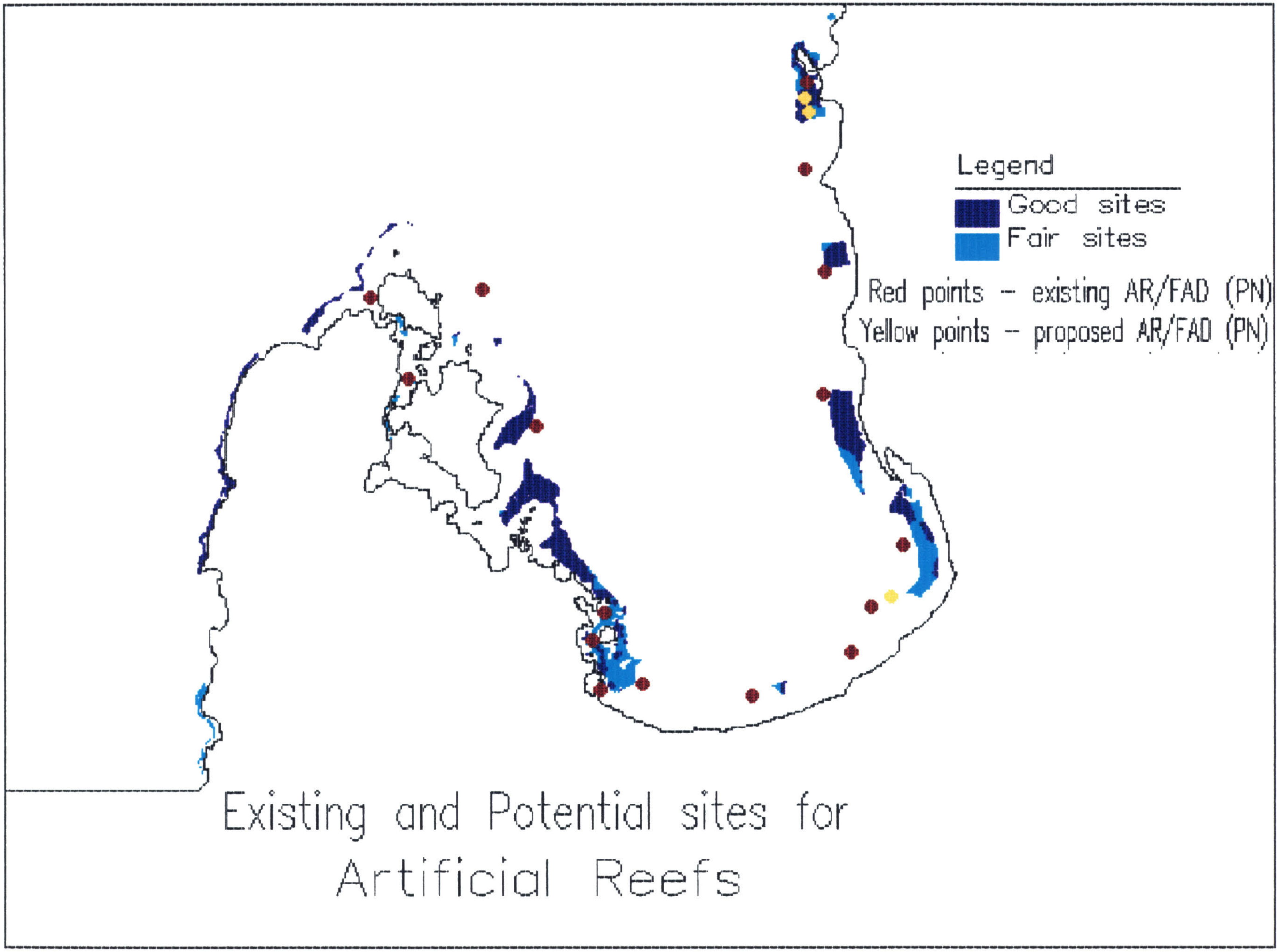
Selection of sites for Artificial reefs

ARs are man-made structures that are laid down at the sea bed for the purpose of enhancing the population of marine organisms by serving as shelter, habitat, breeding area and source of food (White et al. 1990). ARs have been installed in Lingayen Gulf since 1981 following the success of the Silliman University ARs program in 1977 and the establishment of a national program on ARs in 1981 (Miclat and Miclat 1989). About 15 ARs made of either tires or bamboos were established in the gulf. At present, their status are not known. Recently, the Philippine Navy has installed several ARs in Lingayen Gulf (Fig. 1). Site selection criterion was based on close proximity to coral reefs, particularly in areas where corals once thrived.

In this study, the site selection criteria for ARs from Miclat and Miclat (1989) and White et al. 1990 were used to determine suitable areas within Lingayen Gulf. Some modifications on the criteria were made due to lack of quantitative data such as currents and flow patterns of river into the gulf including actual bottom topography. By and large, the procedure used here would be useful as a first stage site selection process which effectively narrows down the areas that can be further examined in greater detail. As shown in Fig. 2, there were two categories used in the site selection process: good and fair sites. Good sites generally met all the criteria for site selection, particularly in terms of bottom substrate while fair sites met some of the criteria. Area analysis showed that there were about 8,520 ha of good sites and 4,492 ha of fair sites (a total of about 6% of the gulf area). Large areas are located in San Fernando, Caba, Agoo, Sto. Tomas, Alaminos, Anda and Bolinao. Comparison with Kitamado (1984), suitable sites in this study encompassed the assessed sites. Comparison with the Philippine Navy (PN) sites, however, showed that only one site fall within the suitable sites in this study while seven are close by. On the proposed sites by the PN, only two fall within the identified sites in this study (Fig. 3). Information on the PN ARs is not available. Possibly, most of these are used as fish aggregating devices (FADs) rather than ARs.

While there are potential areas for siting ARs in the gulf, previous attempts have not been successful largely due to institutional problems including blast fishing (Miclat and Miclat 1989). ARs are seen as FADs as well as fishing gear similar to non-mobile set gear like fish corral. Public awareness on the ecological, institutional and socioeconomic significance and purpose of ARs is needed, especially among the fishing communities and the local government as well. The Lingayen Gulf is experiencing many resource management problems such the overexploitation of the gulf's fisheries resources, destruction of critical habitats and changes in faunal composition (Silvestre et al.


Legend
Good sites
Fair sites
Potential sites for artificial reefs
(First stage selection)


Legend
Good sites
Fair sites
Red points – existing AR/FAD (PN)
Yellow points – proposed AR/FAD (PN)
Existing and Potential sites for
Artificial Reefs

1991, McManus and Meñez 1989, UPV 1990). The use of ARs could be a strategy towards stock enhancement and even conservation. Unless the management issues faced by previous ARs project can be resolved, very limited success could be expected.

Establishment of a Marine Reserve

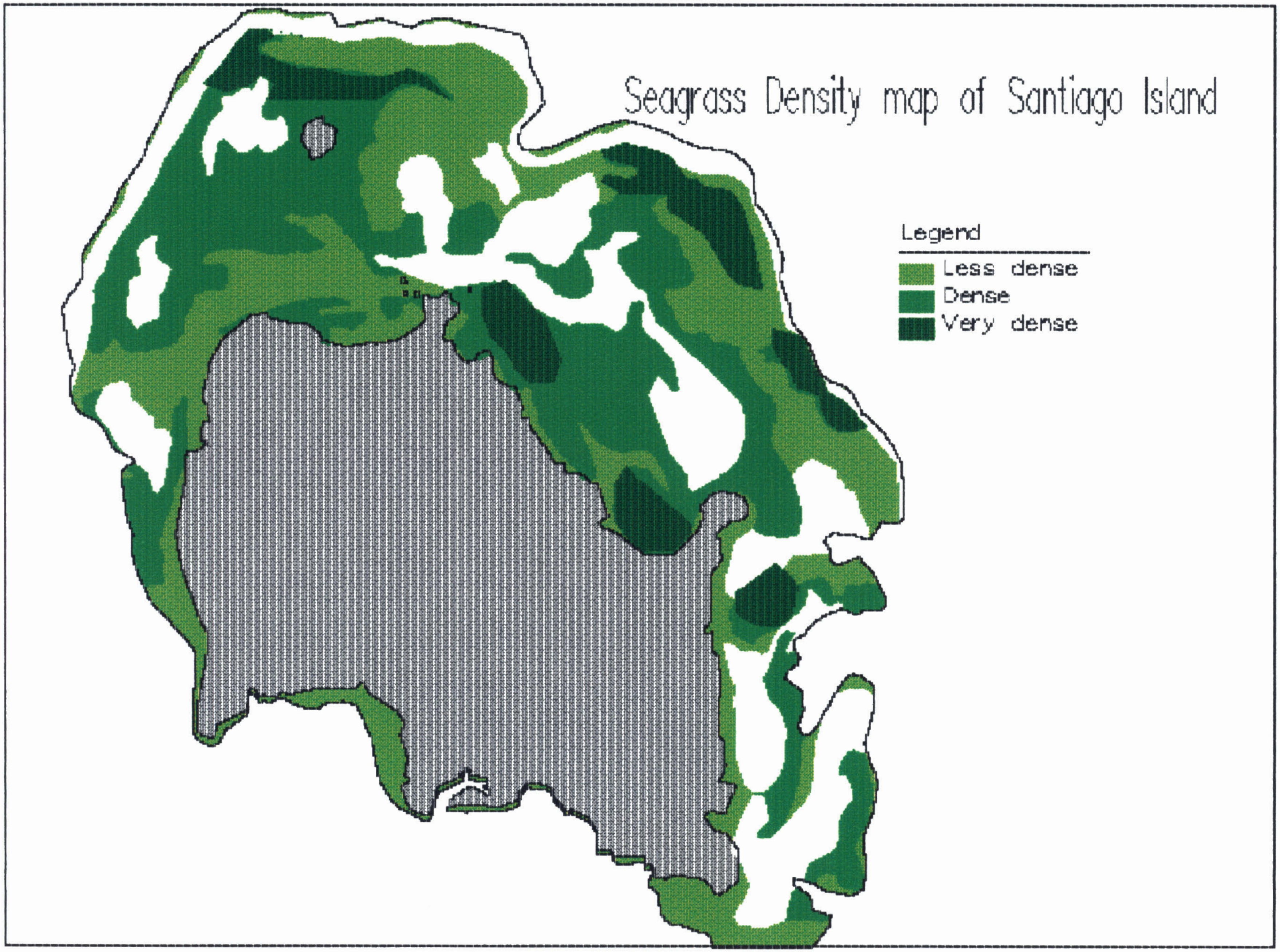
Marine reserve is established for the purpose of conservation, typically refers to coral reef system which is one of most productive ecosystems in the world (White 1988). The goals of marine reserves including protected areas are: (1) to maintain essential ecological processes and life support systems; (2) maintenance of genetic diversity; and (3) guarantee the sustainable utilization of species and ecosystems (IUCN, UNEP and WWF 1980) The establishment of marine reserves is one of the strategies of coastal zone management and also the recommendation of the Lingayen Gulf coastal area management (CAM) plan (NEDA Region I 1992).

Coral reefs in the municipalities of Bolinao and Anda in Western Pangasinan are relatively fair in terms of live coral cover and very extensive. Most of these are fringing reefs. Blast fishing and use of poisons to catch reef fishes for aquaria are major management issues affecting coral reefs not only in Lingayen Gulf but throughout the Philippines. Reef fishing whether by gleaning or the use of gear are important economic activity in Western Pangasinan, providing about 35% in terms of employment for the Bolinao area (McManus et al. 1992).

Among the coral reefs in Bolinao, Santiago Island has extensive reef system with relatively good live coral cover, especially along reef slopes. Seagrass beds are also abundant, supporting an important fishery - siganids or rabbit fish (Fig. 4). Among the areas survey by the University of the Philippines Marine Science Institute, the Malilnap channel area has live coral cover of about 45% (UPMSI 1988). This area has been recommended as a reserve based on the following considerations (McManus et al. 1992):

1. Reef fish density is less than one magnitude that of reefs with low fishing pressure.

2. Large reef fishes declined by 33% and fishers are harvesting smaller fish which could eventually becomes unsustainable.


Seagrass Density map of Santiago Island
Legend
Less dense
Dense
Very dense

3. Protecting a portion of the reef could increase the densities of reef-dependent fishes and invertebrates, enhancing the fisheries resources of nearby areas due to the migratory nature of many species and the dispersion of young fish.
4. Harvestable adult fish could occur in the presence of reserves which will favor economically marginal fishers.

The area covered by the proposed reserve comprises a section of northern Santiago Island in barangay Binabalian. The major features of the marine reserve are (Fig. 5):

1. Land-based component - Pisalayan Point is a breeding ground for sea turtles, mangroves onces existed nearby but this can be reforested. The rocky outcrop harbors large monitor lizards (*Varanus salvator*) and birds. A fishfarm is sited nearby. The landward boundary of the reserve is tentative the fishfarm.

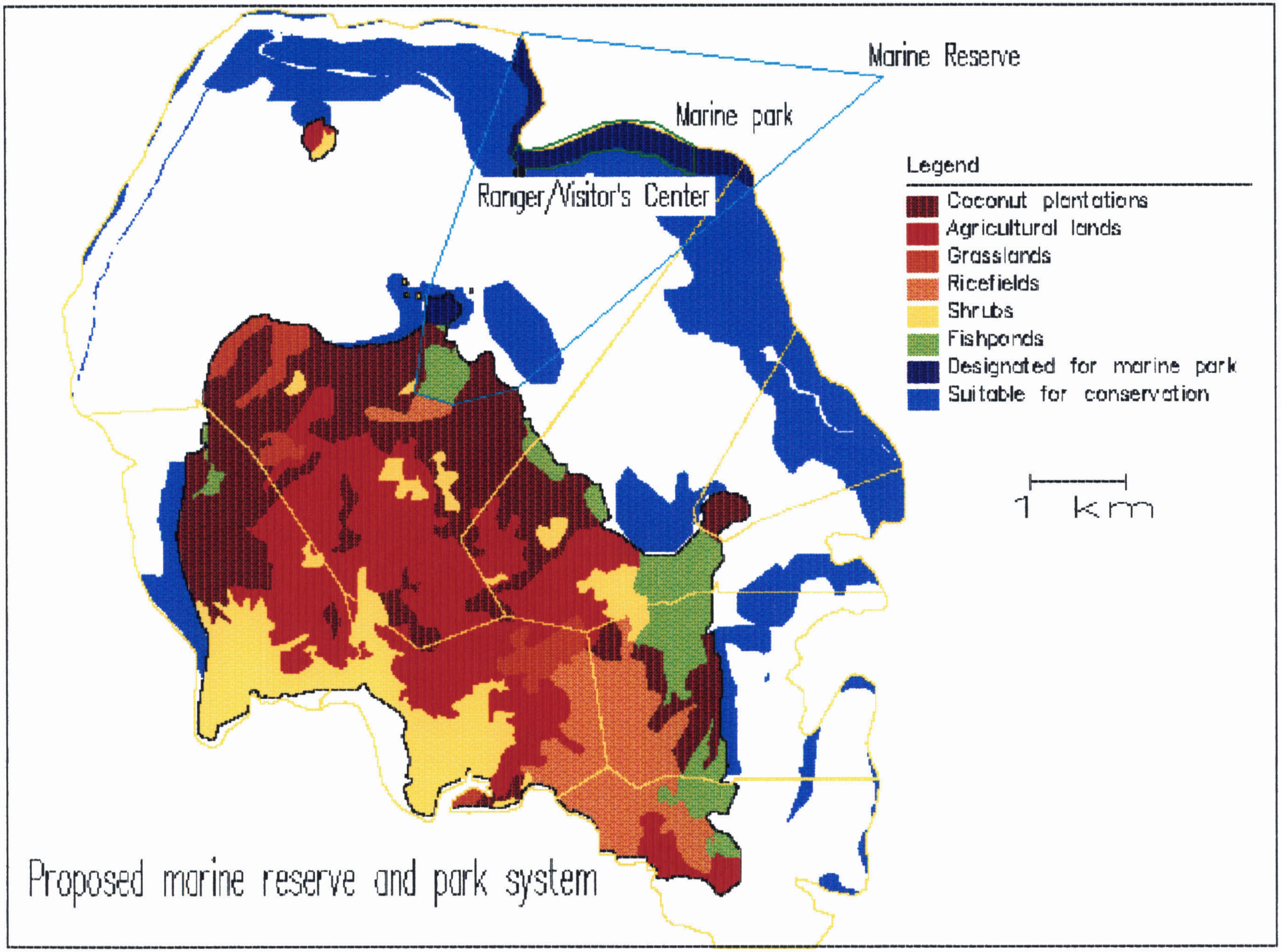
2. Marine component - Between Pisalayan Point and the marine park is an area of seagrass of variable densities. It is an area where siganids are fished. A ranger station should be sited close to the marine park which will monitor activities within the reserve as well as the park.

3. Marine park - this will be the area extending from the ranger station to the reef slope following the Malilnap Channel. Harvest of any forms will not be allowed. Only supervised recreation and scientific activities will be allowed.

The establishment of a marine reserve will not only enhance the fisheries resources of Santiago Island and nearby waters but it could also attract nature-oriented tourists such as SCUBA diving groups. If properly implemented and with adequate public awareness program and political support, the benefits that will be accrued from such reserve can improve the lot of fishers.

Conclusion

The fisheries resources of Lingayen Gulf have been overexploited and critical habitats are in various states of degradation. Enhancement of the resources is clearly needed and the establishment of ARs and marine reserve are viable management strategies. In this study, substantial areas of the gulf are promising ARs sites. ARs have been established in Lingayen Gulf but with very limited success due to institutional constraint and low public awareness on its ecological role. Most of the ARs projects are uncoordinated efforts by either government or nongovernment organizations. It is important, therefore, that



Proposed marine reserve and park system

implementation of ARs must be structured as an integral part of coastal zone management (IPFC 1990).

With respect to marine reserve, an area in Santiago Island has been proposed. Large-scale mapping is still needed to demarcate actual reserve boundaries. Socioeconomic, institutional and legal issues must be identified and appropriate measures taken in order that such reserve can be established.

Acknowledgement

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Establishing a Zonation Scheme for Lingayen Gulf, Philippines

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Abstract

The Lingayen Gulf coastal area is undergoing rapid economic development. Existing demographic and economic activities are already exerting significant pressures on the coastal resources. New development programs, particularly on tourism and industrialization will compound the situation. One strategy to ensure the sustainable development of the gulf area is the establishment of a zonation scheme. A first approximation of such a zonation is proposed. The formulation of the zonation scheme and its limitations are discussed.

Introduction

Increasing population and economic development in the Lingayen Gulf coastal area are exerting pressures on the scarce coastal resources which are in various states of degradation. In particular, the many and diverse human activities constitute imposing, excessive, and competitive demands on these natural resources.

Because of the intensity and diversity of activities in the Gulf's coastal area, management strategy such as zonation, is necessary to ensure a balance between public use, economic development, environmental protection and conservation. This involves the designation of areas for particular uses in accordance with the goal of sustainable development enunciated both in the Regional Physical Framework Plan (RPFP) and the Lingayen Gulf Coastal Area Management Plan (CAM plan).

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In late 1991, the Geographic Information Systems for Coastal Area Management and Planning (GISCAMP) Project was implemented with the International Center for Living Aquatic Resources Management (ICLARM) as the executing agency and the National Economic and Development Authority Region I Office (NRO) as the collaborating agency. Funding support was provided by the International Development Research Centre of Canada (IDRC) with counterpart contributions from ICLARM and NRO. The initial task of the project was to undertake spatial data management using geographic information systems (GIS) and subsequently into the development of a zonation scheme for the gulf as recommended under the CAM plan. The scope of the zonation scheme was broaden to include new economic development earmarked for the area which are not adequately considered in the CAM plan as well as complementing the RPFP. This paper describes the development of a draft medium-term zonation scheme for Lingayen Gulf.

Methodology

The formulation of the zonation scheme for the Lingayen Gulf Coastal Area involved three major steps: a) the formulation of a development pressure map from the existing as well as proposed development activities, programs and projects in the area as contained in various development plans, b) the refinement of the potential areas for coastal use such urban/settlement expansion, brackishwater aquaculture, mangrove rehabilitation, tourism, marine park and artificial reefs, considering the various development pressures from the development plans, existing development undertakings and natural hazards, and c) the establishment of the overall zonation scenario by integrating the refined potential areas against the backdrop of existing land/resource use.

The Development Pressure Maps were first established using the information and data gathered from the six development/management plans for Region I (Medium-Term Regional Development Plan (MTRDP), RPFP, CAM plan, Regional Tourism Master Plan, Northwestern Luzon Growth Quadrangle Master Plan and Fast Track: Towards Pangasinan 2000). Each of these plans has specific programs/projects that usually with spatial component. The development pressure maps are used to determine the potential or future development activities in the study area.

The generation of development pressure maps involved several steps:

1. All the programs/projects in each development plan that will be implemented within five years, whether in the long- or medium-term plans, were determined.

2. These projects per plan were prioritized according to the criteria set by the NRO I sectoral units. Two levels of prioritization were used to come up with development pressure maps.

   a. Under the first level, two prioritization stages were used. The first stage was based on each project's social and economic desirability, environmental integrity, cost and financing, and regionwide effects. The second stage was based on each project's implementability with consideration of the result of the first stage prioritization, funding support, feasibility study and implementation schedule. A Delphi method was used in the prioritization in which five sectoral staffs of NRO I prioritized the projects per plan.

      From the result of the first level prioritization, all the programs/projects per plan were tabulated according to their respective prioritization scores. These were then plotted on a map (project map per plan) using GIS. The GIS software used is called SPANS.

      Some projects in each plan have no specific location and/or area, thus, aside from plotting vectors and polygons, point data were used in which a zone of influence (buffer) was constructed around each point based on its probable impact as derived from existing information.

   b. The second level of prioritization involved another two stages. The first stage covered the prioritization of the plans based on each plan's social and economic desirability, environmental integrity, cost and financing and regionwide effects. Due to the compatibility, if not repetition/reiteration of the RPFP and the MTRDP as far as programs/projects are concerned, these were combined as one plan in the prioritization process.

      The second stage involved the prioritization of the programs/projects across plans. This was done by multiplying the rank of each project (second stage, first level ranking) by the rank of each respective plan. The project with the lowest score was ranked the highest. In cases where there were area overlaps among the projects, the project with the lower score was considered. For example, when two projects from two differing plans overlapped, the project with lower score was considered; when three projects from three differing plans overlapped but two of them are the same project, the average score of the two projects was compared with the score of the other project, and whichever had the lower score prevailed.

CRITERIA FOR PROJECT PRIORITIZATION
(FIRST LEVEL)

NOTE: IT IS A PRECONDITION THAT THE PROGRAMS/PROJECTS TO BE PRIORITIZED ARE CONSISTENT AND SUPPORTIVE OF THE REGIONAL THRUSTS AND STRATEGIES OF REGION I

PRIORITIZATION CRITERIA AND WEIGHTS

A. FIRST STAGE

1. Economic Desirability------------------------------35 pts.

   a. generation of employment opportunities 6

   b. generation of net foreign exchange 6

   c. impact on sectoral targets and objectives 6
   (production level, growth rate, productivity)

   d. increase in income levels 5

   e. promotion of the region's comparative advantage 4

   f. potential for backward/forward linkages 4

   g. promotion of a more equitable distribution of income 4

2. Project has no Adverse Environmental----------------18 pts.
   Effects (e.g., public health; land, air and water pollution; destruction of critical habitats; and erosion)

3. Project Cost and Financing--------------------------18 pts.

   a. project has revenue generating capability 9

   b. project does not require excessive budgetary counterpart 9

4. Social Desirability -------------------------------- 18 pts.

   a. improvement in the level and quality of community services 6

   b. development of the full potential of human resources in terms of health, education, and skills, and its effective harnessing through productive employment 6

   c. promotion of a stable social and political environment (peace and order, discipline, etc.) 6

5. Project has Regionwide Effects ---------------------- 11 pts.

TOTAL -- 100 pts.

PROPOSED CRITERIA FOR PROJECT PRIORITIZATION

PRIORITIZATION CRITERIA AND WEIGHTS:

1. Relative impact on regional growth and overall economic performance (i.e., consistency and support to regional thrusts and strategies) ------------------------------------ 16 pts.

2. Economic Desirability:

   a. Generation of employment opportunities ------------ 8 pts.

   b. Generation of net foreign exchange ---------------- 8 pts.

   c. Impact on sectoral targets and objectives (production level, growth rate, productivity) ------------------------- 5 pts.

   d. Increase in income levels ----------------------- 4 pts.

3. Project has no adverse environmental effects (e.g., public health; land, air and water pollution; destruction of critical habitats; and erosion) -------------------------- 16 pts.

4. Project Cost and Financing:

   a. Project has revenue generating capability ------------------------------------- 8 pts.

   b. Project does not require excessive budgetary counterpart -------------------------- 7 pts.

5. Social Desirability:

   a. Improvement in the level and quality of community services ---------------------------- 4 pts.

   b. Development of the full potential of human resources in terms of health, education, and skills, and its effective harnessing through productive employment ----------------- 7 pts.

   c. Promotion of a stable social and political environment (peace and order, discipline, etc.) ----------------------- 7 pts.

6. Project has regionwide effects ----------------------- 10 pts.

TOTAL -- 100 pts

CRITERIA FOR PLAN PRIORITIZATION

CRITERIA AND WEIGHTS

1. Economic Desirability ------------------------------ 35 pts.

   a. Generation of employment opportunities 10

   b. Promotion of the region's comparative advantage 9

   c. Potential for backward/forward linkages 8

   d. Promotion of a more equitable distribution of income 8

2. Plan promotes environmental integrity ---------------- 18 pts.
   (e.g., public health; land, air and water; critical habitats; etc.)

3. Plan Cost and Financing ------------------------------ 18 pts.

   a. Plan contains/defines projects with revenue generating capability 9

   b. Plan contains/defines projects which do not require excessive budgetary counterpart from government 9

4. Social Desirability ---------------------------------- 18 pts.

   a. Improvement in the level and quality of community services 6

   b. Development of the full potential of human resources in terms of health, education and skills, and its effective harnessing through productive employment 6

   c. Promotion of a stable social and political environment (peace and order, discipline, etc. 6

5. Plan has regionwide effects -------------------------- 11 pts.

TOTAL -- 100 pts.

3. All the project maps per plan were combined through a non-weighted map overlay method which generated a table with a corresponding map. Two separate maps were generated from the reclassification of the table. The map with projects having area overlaps were classified whether they are complementary with each other, conflicting, neutral or conflicting but can be managed. In the other resultant map where projects did not overlap, the first ten with the lowest scores were considered the highest priority projects, the next fourteen - higher priority projects, the other next fourteen - high priority projects, and the rest are priority projects.

4. A separate map showing the location of existing industries and agrolivestock facilities was also generated. The resultant maps from these series of steps are the Development Pressure Maps.

5. Using these development pressure maps, the potential areas for settlement expansion, tourism, mangrove rehabilitation and aquaculture were refined.

    a. The potential settlement expansion areas were assessed in terms of their vulnerability to natural hazards (i.e., whether these fall within severe flooding and fault zones) as well as their proximity to existing and proposed industrial areas/zones, both pollutive and non-pollutive.

    b. The potential tourism zone was refined by adding on the proposed tourism sites. This was the scenario followed - rather than the reverse of refining the proposed projects on the basis of the potential tourism sites, - as the projects considered have already been approved by the Regional Development Council[3] on the basis of feasibility studies prepared on such proposed projects.

    c. The refinement on the potential aquaculture and mangrove rehabilitation areas was in terms of delineating the overlapping sites of these uses as well as with tourism. While these three uses are not necessarily conflicting, the overlaps have been determined to highlight the requirements for management measures different from the "single use"/non-overlapping areas.

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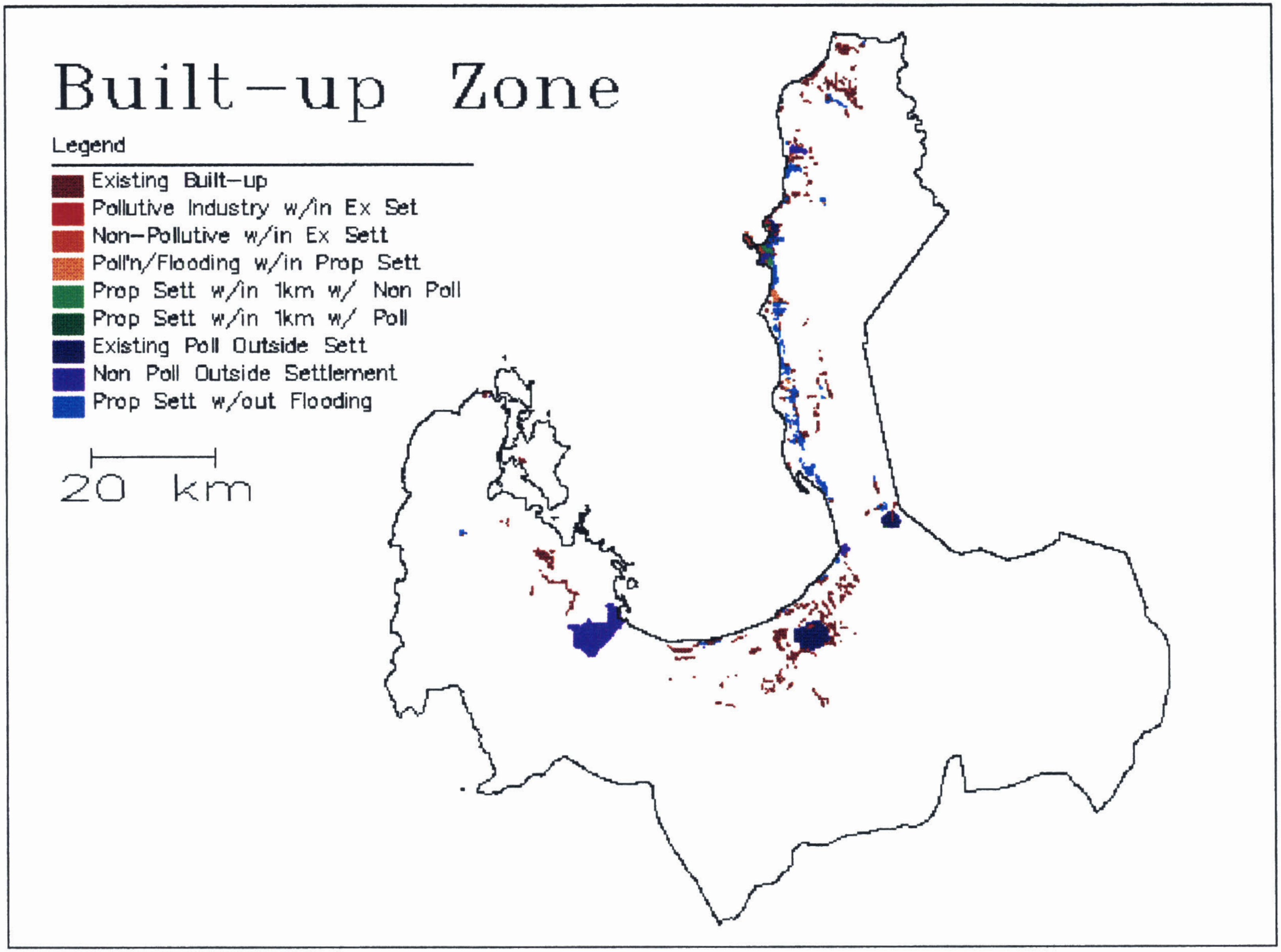
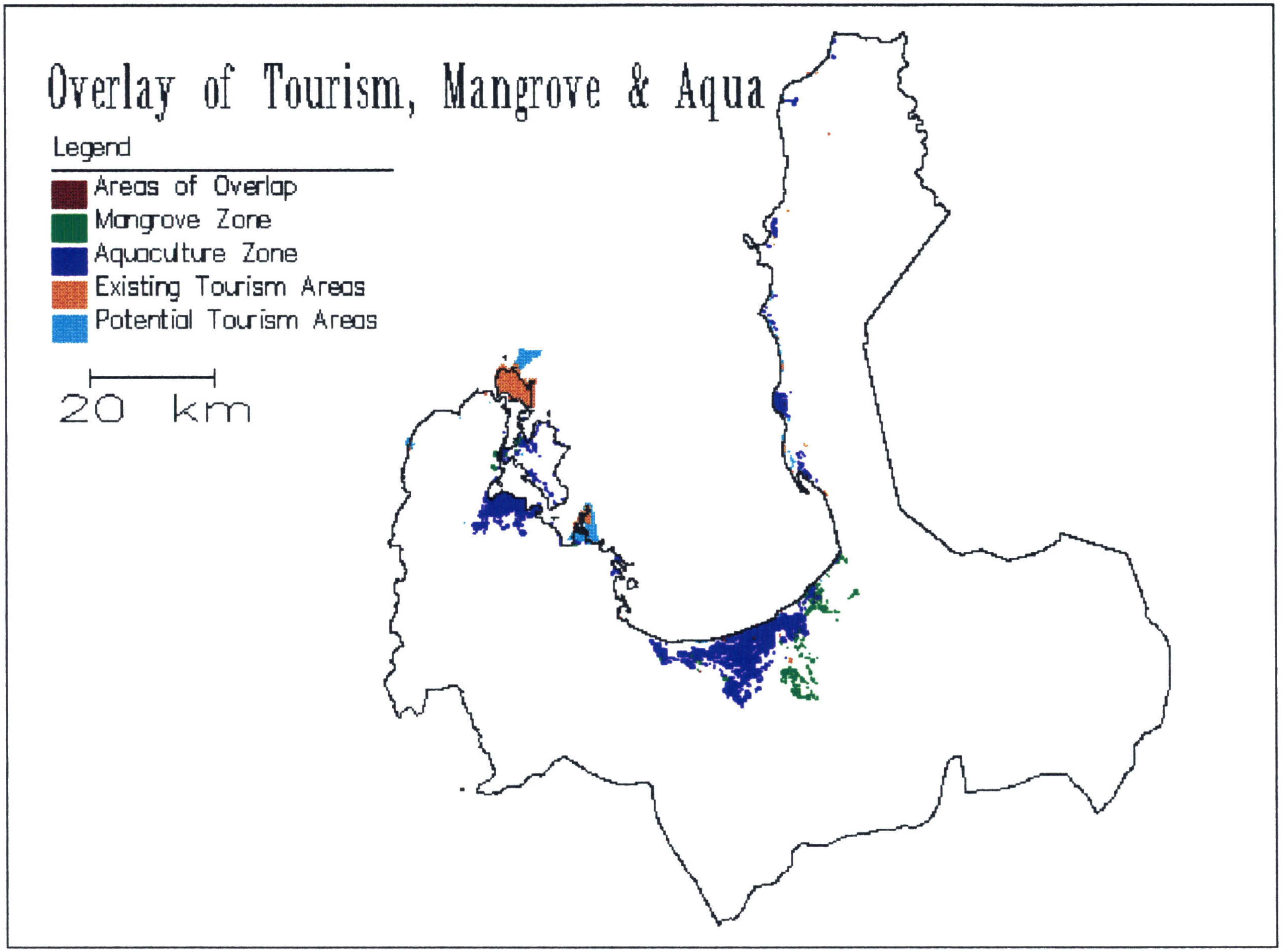
3 The Regional Development Council coordinates the planning and implementation of development programs and projects at the regional level.


Built-up Zone
Legend
Existing Built-up
Pollutive Industry w/in Ex Set
Non-Pollutive w/in Ex Sett
Poll'n/Flooding w/in Prop Sett
Prop Sett w/in 1km w/ Non Poll
Prop Sett w/in 1km w/ Poll
Existing Poll Outside Sett
Non Poll Outside Settlement
Prop Sett w/out Flooding
20 km


Tourism Zone
Legend
Existing Natural Sites
Existing Historical Sites
Man-made Sites
Existing Cultural Sites
Existing Religious Sites
Existing Marine Based Tourism
Potential Natural Sites
Potential Forest Sites
Proposed Projects
20 km


Overlay of Tourism, Mangrove & Aqua
Legend
Areas of Overlap
Mangrove Zone
Aquaculture Zone
Existing Tourism Areas
Potential Tourism Areas
20 km

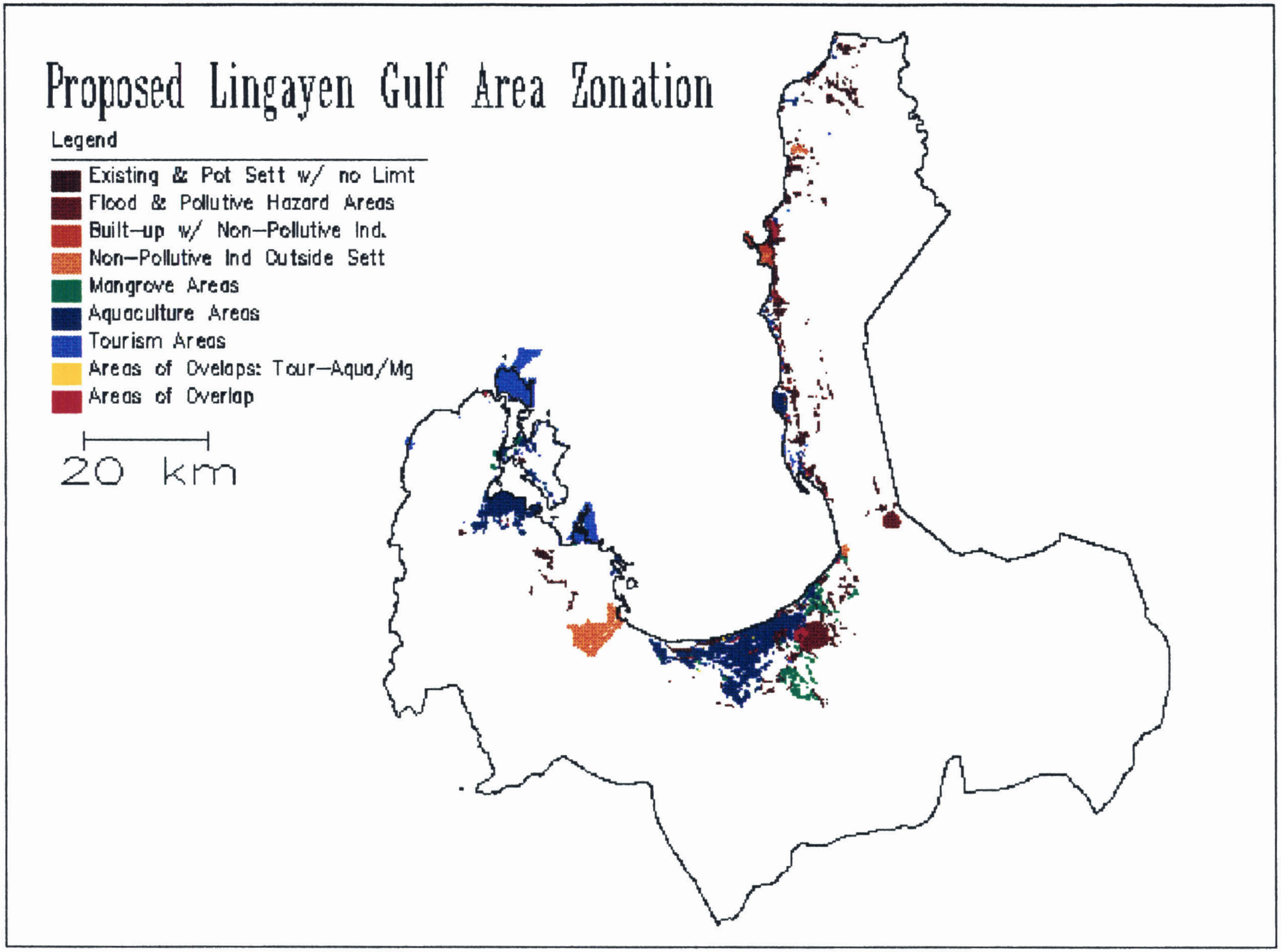
The overall zonation scheme was arrived at by overlaying the refined maps and the reclassified 1990 land use map with the following categories: agricultural cropland, forestland, settlement/built-up areas, fishpond/mangrove/swamps, tourism zone and special management zone consisting of special miscellaneous use zone, hazard (flood and pollutive) zone and areas of overlap.

Results and Discussion

Development in the Lingayen Gulf coastal area has accelerated in recent years, especially toward industrialization. Existing demographic pattern and economic activities are already exerting tremendous pressures on the coastal resources which are either scarce or deteriorating. New developments will certain exacerbate the myriad management problems facing the gulf area unless proper strategies can be emplaced to cushion the pressures. One such strategy is the establishment of a zonation scheme. This paper discussed the terrestrial component of the zonation scheme. The marine zonation is discussed separately (see Paw et al. 1994 in this volume).

Presently, there are six priority development and management plans for Lingayen Gulf area which also cover most of Region I. These are the MTRDP, RPFP, CAM plan, Regional Tourism Master Plan, Northwestern Luzon Growth Quadrangle Master Plan and Fast Track: Towards Pangasinan 2000. Many of the programs/projects from each of the plans either overlapping or complementary. In the mapping and prioritization of projects, there are 18 instances of overlapping projects in the two provinces (i.e., La Union and Pangasinan), indicating that there are different projects proposed in the same or adjacent locations or within the same influence areas. The activities or resource uses involved in these areas of overlap, however, are all complementary or compatible rather than conflicting. Some of these site-overlapping projects include the Poro Industrial Development and the Pangasinan Industrial development projects with the Philippine National Railways rehabilitation project passing through Pangasinan from Manila to San Fernando, La Union; the Poblacion of Alaminos road improvement and the Hundred Islands development project in Alaminos, Pangasinan; and the sweet potato production and the Agno-Waig irrigation project, also, in Pangasinan.

In terms of project priorities, most of the top five priority projects for all the plans considered, except the CAM plan, are infrastructure projects. These include airport and road improvement projects supportive of both tourism and industrial development, especially concentrated within the coastal zone. The resource rehabilitation and improvement project priorities, on the other hand, are located in the eastern part of Pangasinan where the degraded forest areas and croplands are located. The latter set of project priorities augurs well for the


Proposed Lingayen Gulf Area Zonation
Legend
Existing & Pot Sett w/ no Limt
Flood & Pollutive Hazard Areas
Built-up w/ Non-Pollutive Ind.
Non-Pollutive Ind Outside Sett
Mangrove Areas
Aquaculture Areas
Tourism Areas
Areas of Ovelaps: Tour-Aqua/Mg
Areas of Overlap
20 km

coastal rehabilitation measures being proposed in the CAM plan as it was found out that a number of the coastal resource degradation problems in the Gulf find their origin in the watersheds in Eastern Pangasinan.

In the areas identified for settlement or built-up expansion within the coastal zone, the most suitable, considering such other factors as proximity to industrial employment opportunities and relative safety from flooding problems, are within a stretch from San Fernando to Bauang in La Union. There is likewise a long stretch of fairly suitable settlement expansion areas along the national road from Bauang to Rosario, indicative of a continuing ribbon pattern of development in La Union. The suitable expansion areas within the "Metro Dagupan" area in Pangasinan are near existing pollutive industries, thereby requiring the continuous monitoring of pollution levels and the implementation of pollution-control measures in these areas.

There are some areas of overlap for tourism, mangrove and aquaculture uses within the zone. These are located along the Aringay to Sto. Tomas stretch in La Union and in Binmaley and Lingayen in Pangasinan. These overlaps can be compatible so long as prescribed conditions are met following the guidelines on town planning for coastal municipalities set by the then Ministry of Human Settlement. For instance, passive and non-destructive tourism and recreation activities may be allowed in forest/mangrove rehabilitation areas provided conservation measures are observed.

In the proposed Lingayen Gulf area zonation (first approximation, i.e., only the refined potential sites excluding existing use areas), the biggest proportion of the areas are proposed for settlement and aquaculture use constituting 25% and 38% of the potential sites, respectively. Potential tourism areas, on the other hand, constitute around 9% while mangrove at around 7%.

Around 10% of the total potential areas are for special management as these are very suitable or suitable sites for settlements but with such limitations as flooding or industrial pollution or are areas of overlap between mangrove/aquaculture and settlements/built-up. These areas would also include those suitable for mangrove rehabilitation within predominantly aquaculture areas or settlement expansion zones within flood-prone areas. In the case of the former, it is necessary to guard against further conversion of mangroves into aquaculture areas while in the latter, the proper flood control measures shall be provided to protect the inhabitants in the area.

Conclusion and Recommendations

It is generally accepted that the coastal zone - the area where the land meets the sea - is a significant component of the Philippine environment considering the archipelagic nature of the country. In the Ilocos Region, the Lingayen Gulf coastal zone, despite its degraded and overutilized state, is still considered an important resource. It has remained to be the main source of fish supply for the region and its adjoining regions including Metro Manila. The gulf area is being projected as centerstage of the region's development efforts for the rest of the years ushering in the 21st century. The major development plans of the region target the area as the location for intensified industrial and tourism activities that are intended to generate the growth and development of the region. As such, not only are industrial centers expected to be established in the Sual-Dagupan-San Fabian stretch but key tourism destinations are proposed to be developed in the Alaminos-Bolinao and the Bauang-Agoo beach areas.

This zonation scheme for the Lingayen Gulf area is being proposed to provide a basis for the Local Government Units and line agencies operating in the area to direct and/or regulate the utilization, rehabilitation and management of the resources in the area. The zonation scheme shall serve to indicate - but not to mandate - the desired uses of both the terrestrial and aquatic resources in the Gulf.

The zonation scheme herein proposed is a first approximation of the potential and desirable uses of the resources in the area. Its formulation suffered deficiencies in data and analysis, among which are the climatological conditions within the zone, water quality, coastal resource utilization rates, and the analysis of impacts - both beneficial and adverse - of resource utilization and socio-economic conditions of the areas. Nonetheless, the scheme provides a response to the competing demands on the Lingayen Gulf coastal resources and capabilities, namely recreation/tourism, economics and environmental preservation.